END-USER DEVELOPMENT FOR KNOWLEDGE SHARING
A Collaborative Web Mapping Application in the First Aid Domain

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Abstract: This paper describes FirstAidMap, a collaborative web mapping system for creating, managing and sharing territorial knowledge that can be useful in case of emergencies. The system arises from a design experience we have carried out with representative end users belonging to an association for public assistance and first aid. Volunteers of this association, and specifically ambulance drivers, need to know the characteristics of the territory where they ensure their assistance, in order to reach a given place quickly and in a safe manner. This knowledge is often tacit and usually distributed among the members of the association. Currently, to cope with this problem, paper-based maps are the only means to spread and share knowledge within the association; while training sessions are regularly taken to provide drivers with information about the dangers existing in the territory and possible viability modifications. Representative volunteers participated in the design of FirstAidMap and in the study of end-user development functionalities that could make all volunteers able to contribute their own knowledge and share it with the other volunteers. The resulting system engages and motivates users to participate in map shaping and, at the same time, reinforces the sense of community and individual awareness.

1 INTRODUCTION

With the advent of the World Wide Web and particularly of the participatory web, or Web 2.0, (O'Really, 2006), maps are increasingly the venue where people with different expertise can meet and share knowledge for a specific purpose. As suggested in (Marcante and Parasiliti Provenza 2008), web maps become *social media*, where users are not only able to access and modify the information associated with the map, but also to act on the information added by other users, and thus interact directly or indirectly with other people by sharing and exchanging knowledge.

Additionally, more and more often web-based maps are collaborative web mapping systems, namely virtual spaces created by end users and totally shaped at their hands. Collaborative web mapping systems, such as Google Maps, allow users to visually define spaces by enabling them to choose what to map according to their own goals, knowledge and practices. Thanks to the contribution of new cartographic content, the resulting map provides a living account of space as a social product of individual embedded knowledge, daily practices, and concerns (Giaccardi and Fogli, 2008).

In this sense, collaborative web mapping systems, are *intrinsically* end-user development (EUD) environments. As effectively summarized by Fischer, EUD "is focused on the challenge of allowing users of software systems who are not primarily interested in software per se to modify, extend, evolve, and create systems that fit their needs" (Fischer, 2010). Indeed, collaborative web mapping systems should encompass socio-technical EUD mechanisms for supporting and encouraging user participation in contributing content and mapping space, especially when the map represents a fundamental knowledge source sustaining users' daily practices. This happens for example in FirstAidMap, a collaborative web mapping system we have designed and developed to satisfy the needs of COSP (Centro Operativo Soccorso Pubblico), an Italian non-profit association for public assistance and first aid. FirstAidMap is a map-based system that supports COSP volunteers in acquiring, creating and sharing knowledge about the territory where COSP ensures its assistance. This knowledge is crucial for ambulance drivers to decide, in case of emergencies, how to reach a given place quickly and in a safe manner. However, knowledge of the territory is often tacit and anyway distributed among

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COSP volunteers, depending on their interests, attitudes, and experiences. FirstAidMap has thus been conceived as a virtual space that users (COSP volunteers) can directly shape and enrich, thus actively building knowledge on the territory and share it within the community they belong to. While interacting with FirstAidMap to make this virtual space evolve, users behave as end-user developers: indeed, they modify 'at use time' the system to satisfy their individual and collaborative needs. Moreover, representative users participated 'at design time' in the development of the system. Their contribution was fundamental to create a system not only easy to learn and to use, but also acceptable by the COSP community and trustable by all its members.

The paper is structured as follows. Section 2 introduces the first aid domain. Section 3 describes the participatory design activity carried out with representative COSP volunteers; in particular, this section discusses EUD needs emerged during design sessions and the main ideas for satisfying these needs. Section 4 describes the main characteristics and functionalities of the resulting application. Section 5 compares our work with related literature, while Section 6 concludes the paper.

2 THE FIRST AID DOMAIN

COSP (Centro Operativo Soccorso Pubblico) is an Italian non-profit association in Mazzano near Brescia for public assistance and first aid (http://www.cospmazzano.it). It includes about two hundred volunteers working together to provide initial care in case of medical emergencies. An ambulance is available 24 hours a day at the COSP's offices. Volunteers are required to attend a certified course for first aid training. Some of them are trained to drive the ambulance and/or to act as specialized rescuers assisting a nurse or an emergency physician from the local hospital in the provision of first aid. In addition to first aid service, COSP association also offers assistance during sport contexts and demonstrations as well as in transporting patients between places of medical treatment.

In this domain, navigator satellite systems, which ambulances are usually equipped with, are not considered sufficient and satisfactory by COSP volunteers to carefully assist ambulance drivers and the whole emergency crews in bringing medical care to serious patients timely. Current navigator systems do not take into account critical issues when suggesting quickest paths to a place, such as roads with humps or uneven road surfaces (really dangerous in case of patients on board), road yards in progress or weekly open-air markets causing detours that can irreparably delay the provision of first aid. Due to these limitations, COSP volunteers do not rely too much on navigator systems, but they rather prefer trusting in their knowledge and expertise of the territory to decide how to reach a given place quickly and in a safe manner. Consequently, COSP volunteers go on using traditional paper maps annotated with their comments and notes; however, due to the rapid topography updates and the perishable nature of paper maps, quick ageing of such traditional maps makes it difficult accessing up-to-date information.

It is thus evident that a web-based mapping system, customized to the specific needs of the intended user community, may represent an effective solution to the problem at hand.

3 PARTICIPATORY DESIGN OF FIRSTAIDMAP

In a first meeting we had with representative COSP volunteers, they specifically asked for a map-based software system that supports the training activity of new ambulance drivers, who need to know the characteristics of the region where COSP ensures its assistance. Indeed, a high percentage of interventions are performed in the neighbourhood of Mazzano including about fifteen different villages; as a consequence, drivers often find difficult orienting themselves in this wide territory, especially where interventions are rarely required or when rural areas must be reached. Regular training sessions thus provide volunteers with information about the dangers existing in the territory, including temporary holdups on the roads, and about the preferred roads leading to different zones. A good and up-to-date a priori knowledge of the territory is crucial for guaranteeing fast interventions. The training activity is usually performed by using traditional teaching materials, typically by projecting and describing PowerPoint™ slides with annotated maps of the territory.

Therefore, a first goal was developing a web-based mapping application, called FirstAidMap, to support both instructors during training sessions and drivers in self-training. The application has been designed following a participatory approach (Schuler and Namioka, 1993). Scenarios and use

cases have been used to analyse system requirements with the collaboration of representative users; mock-ups have been prepared and progressively refined to collect feedbacks and suggestions about the map look-and-feel and its interaction possibilities. An iterative approach based on the star-life cycle (Hix and Hartson, 1993) has been adopted to develop the application.

In the following, we first describe the basic requirements identified at the beginning of the project referred to the training activity, and then the needs emerged during the development of the application related to more sophisticated activities of knowledge creation and sharing.

3.1 Requirements Analysis

The activities carried out by driver instructors, and generally by COSP volunteers, are related to their territory and require detailed and up-to-date knowledge about the region where they offer first aid assistance. Therefore, a digital map, commonly used in different geographical systems should be the main component of the FirstAidMap application: its digital nature obviously increases the ability of COSP volunteers to explore information on the map with respect to the traditional paper-based version. For the specific application domain, there is the need of a digital map whose resolution level is high enough to make roads, but also buildings and houses of interest, recognizable. Additionally, the map should be easily 'explorable' by users with limited experience and competencies in information technologies. Consequently, COSP volunteers should easily zoom in and zoom out or pan to better visualize a certain area of the territory.

A digital map, although up-to-date and with a high resolution, does not contain all the information the specific community requires about the territory. From the analysis of the application domain, three types of information have been recognized as crucial for COSP work: *zones, points of interests* and *notifications*. They are all necessary to guide ambulance drivers to the place where medical assistance is needed. In other terms, they are information that enrich the geographic map with semantics relevant for the COSP domain. Let us consider in the following all the three types of information.

A *zone* is an area on the map with common characteristics; it groups together several points on the map that satisfies some condition. An example is a set of roads or neighbourhoods reachable through a same ambulance route from the COSP offices. It is described by a name and eventually by some users' notes characterizing the area.

A *point of interest*, or briefly POI, is a place on the map, i.e. a fixed and stable element on the territory that acts as a reference point for ambulance drivers and can help drivers to find their way to a place. As in navigator satellite systems, a POI can be a church, a sports ground, a square and so forth. However, it can also be a more specific reference point for an ambulance driver such as a bridge, a dangerous road or other points of interest relevant for first aid activities.

Finally, a *notification* is a notice about an alert situation that can interfere with first aid interventions. It aims to notify medical personnel of emergency units about a critical condition occurring in a given place and for a period of time that can hinder the work of COSP volunteers, e.g. work in progress in a specific area of interest or the temporary modification of the road network of a neighbourhood due to a demonstration. Differently from the other types of information, a notification usually has a limited validity (e.g. the closing of a motorway tollbooth due to work in progress) or it refers to an event occurring with a certain frequency (e.g. the open-air market that takes place in a square each Wednesday morning). Therefore, notifications should be displayed on the map in the time frames they are active.

All these types of information contribute to support the activities of COSP volunteers. However, they can be a lot of information which altogether can confuse the user of the map. Therefore to avoid information overload, there is the need to properly organize such knowledge. A possible solution is providing FirstAidMap users with all these information organized in four different levels (see Figure 1): (a) level 0 with the digital map (street, satellite or hybrid map) retrieved through an available web mapping service; (b) level 1 including the zones created on the map; (c) level 2 with the POIs; and finally (d) level 3 with the notifications associated with the map. Moreover, COSP volunteers should have the possibility to change the map level easily, by choosing among a set of available web mapping services. Finally, they should be able to switch among the four information levels independently, by disabling, if needed, those levels they are not interested in.

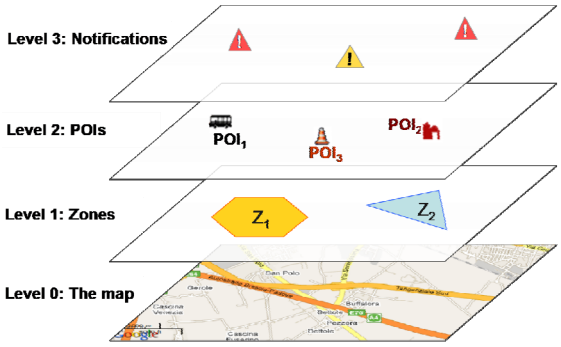

Figure 1: FirstAidMap information levels.

3.2 EUD Needs

During the development of a first prototype satisfying the requirements described above, further discussions with representative users led to identify new usage scenarios, beyond driver training. Particularly, a new need emerged: let COSP volunteers use the system also for simple consultation to improve their knowledge of the territory, and as a support tool while preparing an emergency intervention to identify the characteristics of the area around the ambulance destination place.

In this new perspective of FirstAidMap usage, user collaboration to map enrichment is crucial. Therefore, we started to study how 'to transform' COSP volunteers from passive users into co-designers of map content. This should have required to provide users with proper tools to enrich the map with significant and up-to-date information, along with functionalities for filtering relevant content, customize map visualization and monitoring users' activities. Moreover, this should have to be achieved without forcing COSP volunteers to become expert neither in information technology nor in cartography, as many commercial geographic information systems require.

To face this problem, the ideas and tools proposed in the end-user development field have been considered. The network of Excellence on End-User Development, which was funded by the European Commission during 2002-2003, defined EUD as "the set of methods, techniques, and tools that allow users of software systems, who are acting as non-professional software developers, at some point to create or modify a software artifact" (Lieberman et al., 2006). EUD leads to transfer to end users part of the activities that are traditionally performed by software developers, such as software design, implementation, customization, and adaptation 'at use time'. Particularly, EUD research focuses the attention on those people who use software systems as part of their daily life or daily work, but who are not interested in computers per se (Cypher, 1993). They can be technicians, clerks, analysts and managers who often need to "develop software applications in support of organizational tasks" (Brancheau and Brown, 1993), due to new organizational, business and commercial technologies.

The main goal of EUD is therefore studying and developing techniques and applications for "empowering users to develop and adapt systems themselves" (Lieberman et al., 2006). However, the level of complexity of these activities should be appropriate to the users' individual skills and situations, and possibly allow them to easily move up from less complex to more complex EUD activities. In other words, a "gentle slope of complexity" (Meyers et al., 1992) should be guaranteed, meaning that big steps in complexity should be avoided and a reasonable trade-off between ease-of-use and functional complexity should be always kept in the system. In this way, EUD functionalities should be made available to users progressively, without forcing them to learn advanced functionalities soon. EUD functionalities should not be intrusive nor distract users from their primary task; at the same time, they should encourage users in experimenting system adaptation and modification, by requiring the same cognitive effort necessary for using basic functionalities.

To integrate EUD tools in FirstAidMap, while guaranteeing a gentle slope of complexity, the classes of potential end-user developers have been identified, and then the EUD functionalities the system should offer have been designed. Next subsection discusses these aspects.

3.3 End-User Developers Classification

To allow COSP volunteers to perform different types of EUD activities in FirstAidMap, we started analysing: (i) their current practices within the application domain; (ii) their skills and interests in information technologies; (iii) their motivations in collaborating to knowledge sharing on the map.

This analysis has led us to identify different classes of end-user developers and for each of them we have designed a suitable interaction experience with FirstAidMap. As described in the next section, the result is a collaborative web mapping application that can be effectively adopted within COSP domain and in similar context. The classification of end-user developers is based on the following assumptions,

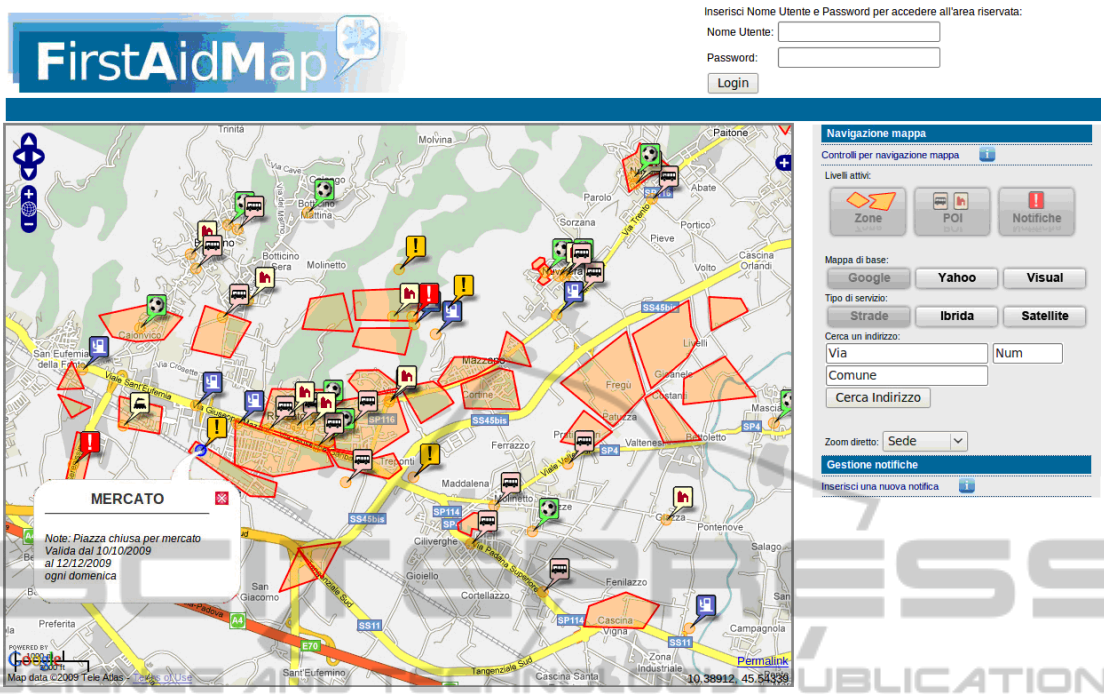

Figure 2: Map view environment.

which have been discussed and agreed upon during participatory design with representative end users.

All COSP volunteers should be able to access the map-based information (zones, POIs and notifications) associated with the map to better know their territory and real-time updates (e.g. detours, hazards). Additionally, they may insert, in an easy and immediate way, a new notification to quickly point out a danger situation. To this end, COSP volunteers should access the system easily without any authentication mechanism. In this case, they access the system as *visitor* users just to explore current information on the map and eventually signal a danger; they should not be allowed to perform more advanced activities.

Some volunteers possibly would like to actively contribute to the updating of map-based information and, consequently, they should be able to create and/or modify zones, POIs and notifications in addition to access and explore the knowledge base as simple visitors. To carry out these activities, volunteers need to authenticate with the system, acting as *contributor* users.

Finally, more active and experienced COSP volunteers should be able to perform more advanced EUD activities to let both the content and the whole system evolve according to the COSP population's needs, thus acting as *administrator* users. An administrator is a power user who manages user profiles, system accesses and all the information associated with the map (POIs, zones and notifications). Furthermore s/he is responsible for configuring the system according to the COSP volunteers' needs.

Furthermore, during a meeting with COSP representative users, a new requirement emerged: among COSP volunteers, ambulance drivers should be required to access the map-based information in FirstAidMap before each emergency intervention, in order to check possible alert situations in the way to the emergency site. To monitor drivers' accesses to the system, a role *driver* has thus been added. As a visitor, a driver user can access the knowledge base, visualize new notifications, and eventually insert new ones, but s/he is required to authenticate to the system to enable the log of his/her activities.

4 FirstAidMap

The resulting application supports EUD activities allowing COSP volunteers to customize the environment and its content, as well as shape what they need. These activities can be categorized as follows:

- Personalization of map visualization by filtering the information available and customizing the map appearance. These

activities span from choosing the type of map displayed (road, satellite or hybrid) or the web mapping service (Google Maps, Yahoo! or Visual Maps) to selecting the information levels to be shown;
- Creation and management of new content, by adding a multimedia document and a marker (a POI or a notification marker) or defining an area (a zone icon) within the map;
- Modification of the type of content to be added to the map and management of system configuration and user profiles.

The application provides an authentication procedure and, as a consequence, different interaction modalities, according to the kind of end user logged in the system. The tools for customizing the map navigation and adding new content have been grouped in a set of panels. Some of them can be used also by simple visitor users who, even if not logged, may interact with the navigation panel and the panel for inserting new notifications. A separated section can be accessed by administrator users: this section does not support a direct interaction with the map, like in the other modalities, but allows creating new kinds of content, managing users, and monitoring drivers activities.

4.1 Accessing as Visitor or Driver

Each visitor user can access FirstAidMap in a consultation mode. In this mode, the user can navigate the map and access content details (see Figure 2). In particular, the user can interact with the map by clicking on the zoom in/out and pan widgets or using the mouse wheel and left button. S/he can also select an icon on the map, so as a pop-up window appears to display its textual details (in the case at hand the pop-up associated with a notification informs about the closing of a specific square due to an open-air market occurring each Sunday from January to December 2009).
On the right of the map there is a navigation panel to allow the user to customize the map visualization by selecting its type (road, hybrid or satellite map) and the web mapping service (Google, Yahoo, Visual Maps). S/he can also filter the map-related information to be displayed (zones, POIs, notifications) and look for a specific place in the map by specifying its address or immediately points to a relevant place from a list, such as the COSP's offices by choosing the "Sede" item.

Under the navigation panel on the right, there is a notification management panel allowing the user to insert notifications only. By selecting "Inserisci una nuova notifica" (Insert a new notification), the corresponding panel is enlarged to support the user in inserting a new notification while the only information level displayed on the map is that with active notifications. This allows the user to focus her/his attention on notifications. The visitor user can thus enrich the map-based information by adding a new notification marker on the map and characterizing it through a name, a description, a validity period, a frequency (all days or a given week day) and a type that represents its gravity.

The same activities can be carried out with FirstAidMap by driver users who logged in the system. The only difference is the monitoring activity performed by FirstAidMap transparently with respect to the user; this activity, as required by COSP, allows checking a posteriori if drivers consulted the map before their emergency interventions.

4.2 Accessing as Contributor

More advanced activities can be performed when the user logs in the system as a contributor. In this case, the map view environment is that shown in Figure 3. As the reader can notice, a richer set of panels is present on the right of the map. This set includes the same navigation panel previously described, and three panels to manage (i.e. insert, modify or delete) zones, POIs and notifications, respectively. The items in each panel can be selected by the user to perform a specific action; the corresponding sub-panel is thus expanded to show all the information necessary to carry out the selected action. Only a sub-panel, and thus only one functionality, can be active at a time. This allows driving more clearly the user during the interaction and reducing error possibilities.

The panel for managing zones includes three sub-panels devoted to zone insertion, zone modification and zone deletion, respectively. By selecting one of these sub-panels, the map is automatically refreshed in order to enable the visualization of the zone level only. This way, the user should better understand the information level where s/he is going to operate. Moreover, in this state of the system, the interaction with the map is different with respect to the interaction allowed by the navigation panel: clicking and moving the mouse pointer on the map in the navigation state determines a dragging of the map and a visualization of a different portion of the territory; whilst, a click on the map in an insertion state leads to the creation of a new point on the map. This permits to reduce

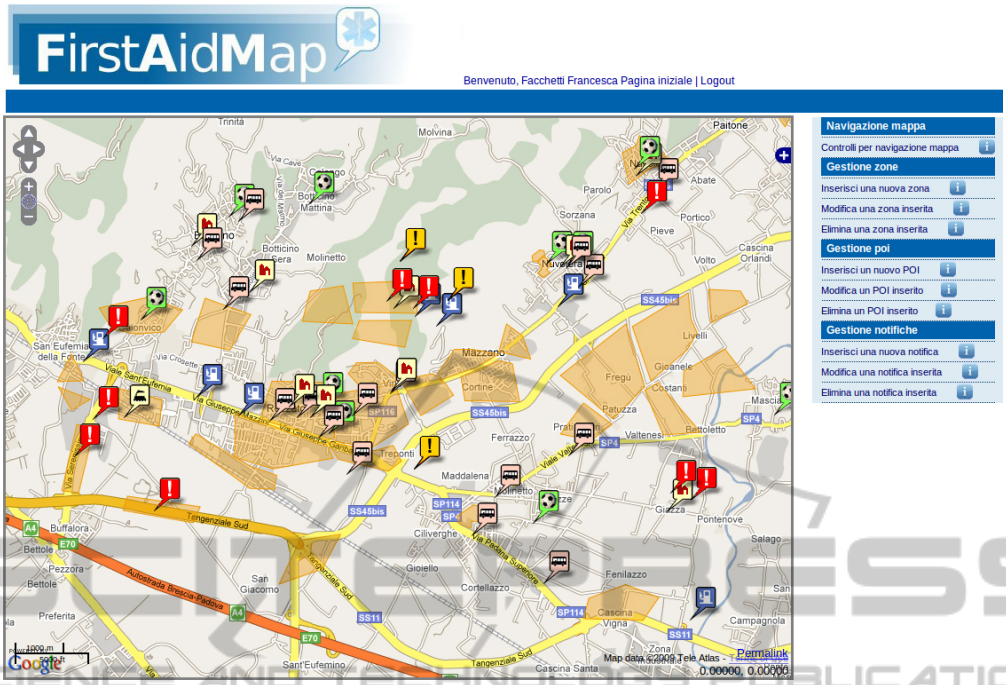

Figure 3: Map view environment for contributors.

errors and to increase user performance while inserting (or modifying or deleting) a content, because in each system state only a limited number of actions can be performed and only the widgets necessary to perform those actions are visualized, without overwhelming the user with too much information and tools.

In the case of zone insertion, a sequence of clicks on the map allows selecting the vertices of a polygon, which is automatically created and adjusted after each user click. A double-click allows completing the polygon draw. Additional information related to the zone, such as a name identifying the zone and a detailed description, can then be inserted by filling in the form that is presented in a sub-panel. This form includes also simple instructions that help a non-expert user in perfoming the task.

The modification or deletion of a zone can be activated by selecting first the corresponding sub-panel of the zone manager panel, then by clicking on a zone on the map. The shape or the position of the zone can be modified by direct manipulation on the map; while the data associated with the zone, which are automatically loaded and visualized in a form, can be changed by just editing them.

FirstAidMap behaves similarly also for managing POIs and notifications. Particularly, for POI insertion, the user can also choose the corresponding icon to be visualized on the map by selecting the POI type (church, soccer field, bridge, etc.).

4.3 Accessing as Administrator

As a member of the COSP staff, an administrator user will not necessarily be an expert in system administration; s/he will be a power user, with some deeper knowledge in information technologies with respect to the other volunteers. The administrator user should therefore be supported in performing administration activities by easy-to-use tools and user-oriented terminology. For this reason, we classify also administration activities within the EUD activities supported by FirstAidMap.

An interesting EUD activity at the hands of an administration user is concerned with the application configuration. Figure 4 shows the page devoted to this activity. At the top of the page the user can select the base map to be loaded at the application start. Then, s/he can manage the types of POIs and notifications by defining new ones or changing the existing ones. The administrator can define a new type by inserting a name and selecting an icon from those avalaible in a group of radio buttons. If the user does not find a suitable icon, s/he can load a new image on the system and this image will then be added to the available icons. The types of POIs and notifications already existing in the application are shown as a list in the bottom part of the page; each

Figure 4: Configuration section.

one is represented by its icon and name, whilst the link "Modifica" (modify) allows the user to access the tool for changing the icon or the name.

5 RELATED WORK

EUD techniques have been used for many years in commercial software, such as macro recording in word processors, formula composition in spreadsheets or filter definition in e-mail clients. However, on the one hand, they are far to be used extensively by a large community of end users, and, on the other hand, there exists the potential for employing EUD techniques in many other application domains and with different levels of complexity (Fischer, 2010). Particularly, EUD-based solutions are advocated in cooperative domains, similar to that considered in this paper. For example, in (Cabitza and Simone, 2009) an EUD approach is proposed to facilitate document-mediated cooperative work in the healthcare domain.

As far as the technical solutions are concerned, component-based approaches for EUD are proposed in the computer-supported cooperative work field (Mørch et al., 2004). Myers et al. focus instead on natural programming languages and environments that permit people to program by expressing their ideas in the same way they think about them (Myers et al., 2004). Annotation mechanisms and visual programming through direct manipulation are the main EUD techniques implemented in software shaping workshops (Costabile et al., 2007). A lightweight visual design paradigm is also proposed in (Spahn and Wulf, 2009), where the approach allows business users to create enterprise widgets.

Moving from domain-oriented systems to more general web-based applications, the approach presented in (Da Silva and Ginige, 2007) is based on the definition of a meta-model of web applications and a set of form-based tools that can be used by end users to customize and shape their applications. A form-based approach is also proposed in (Fogli, 2009), as a way to support the development of e-government services on behalf of administrative employees, who do not have any competences in information technology and neither are interested in acquiring them. Anslow and Rielhe (2008) propose the adoption of Web 2.0 technologies, such as wikis, which are regarded as a platform to support end users not only in contributing content, but also in performing computational tasks, such as the development of business queries. In this line, it has been observed that also mashup makers include much support for EUD (Grammel and Storey, 2008), which usually adopts a model based on composition.

In this work, we have capitalized on these proposals by adopting direct manipulation and form-based interaction as basic means to implement EUD

functionalities in a collaborative web mapping system.

Actually, other systems are available on the Web having many similarities with ours. For example, Google Maps enables users to create personalized maps and share them with relatives and friends. Particularly, users can create their own maps by using place markers, shapes, and lines to define a location, an entire area, or a path. However, the interaction with tools for map personalization is much more programmer-oriented than in our system, with terminology and interaction style resulting to be sometimes intimidating for our classes of users (especially drivers and contributors).

Other systems, such as WikiMapia (www.wikimapia.org) or OpenStreetMap (www.openstreetmap.org) are more oriented toward the creation of a social network rather than of a virtual place where to accumulate and share knowledge for a specific and common purpose. WikiMapia allows registered users to select interesting places by drawing polygons and add text notes about the places, as well as images. Other users can see places, read annotations and add comments. Registered users can also vote for an annotation. If the annotation has more than one vote against it, it is deleted. This parameter, which WikiMapia uses to control the correctness of annotations, is a typical feature of social networks. YourHistoryHere (www.yourhistoryhere.com) is another map-based wiki based on the Google Maps API. It is similar to WikiMapia, since it enables users to mark a place with a flag and to add textual annotations telling the history of the specific place. Other logged users can comment on the history. In all these examples, users who comment on or edit annotations constitute informal groups, characterized by common interests or common knowledge about a same place.

With respect to such systems, FirstAidMap has been designed in a participatory way in collaboration with its intended users, and therefore functionalities for knowledge creation and sharing are tailored to users' skills and experiences, and aimed at satisfying the specific needs of the community. For example, the notion of levels and different kinds of information to be made available at users' pace emerged from the discussions with representative users, as well as the distinctions between POIs and notifications. We argue that these characteristics may better sustain user participation in knowledge creation and sharing, and thus increase the usefulness and meaningfulness of the application.

6 CONCLUSIONS

The experience described in this paper highlights the active role end users may play with respect to a software system both 'at design time' and 'at use time'. However, while user-centred and participatory design approaches are considered by HCI scholars as consolidated and successful practices for interactive system development, only in recent years end-user development (EUD) has received an adequate attention. Differently from participatory design, EUD stresses the role of users as co-designers of their systems 'at use time', and not only 'at design time'.

To support user participation during system usage, Fischer and colleagues (2001) argue that software systems should be designed as living entities, which should be able to grow at the hands of users as if they were *seeds*. FirstAidMap could be regarded as a seed composed by a software system (the technical component) and its users (the social component). As a seed, both its components are able to evolve. Actually, COSP volunteers not only shape the technical environment and make it grow by designing zones or adding POIs and notifications, but they make their own community evolve. Indeed, volunteers become aware of the importance of their knowledge, and thus they become better observers of the territory around them and more willing to inform themselves about the potential dangers, in order to share all the acquired information with the other volunteers. Also the sense of community can change as a consequence of these activities.

We argue that this model could be applied in all those situations where: (i) a community exists or may potentially exist; (ii) the knowledge is distributed among community members; (iii) knowledge changes and evolves in an unpredictable and non-monotonic way; (iv) sharing knowledge comes first than possessing knowledge per se.

To achieve these goals, the EUD tools we have created for FirstAidMap are functionalities that support user participation in collaborative web mapping, and they have been studied to engage, encourage and motivate users in contributing and sharing their knowledge. In general, we argue that both usability aspects and social issues should be carefully considered when designing EUD systems for knowledge accumulation and sharing.

FirstAidMap is developed as an evolutionary prototype to explore the requirements of the COSP community and verify the feasibility of a software system addressing such requirements. At the moment, heuristic usability evaluation and code

testing have been performed by two experts in human-computer interaction and software engineering. The usability problems emerged in this preliminary evaluation have been solved and programming bugs are being fixed. We are currently organizing a systematic evaluation of the application through an experiment with COSP volunteers.

As far as future work is concerned, we are studying the integration in FirstAidMap of more advanced EUD functionalities, such as the possibility for users to create new information levels. We are also re-engineering the application to make it flexible enough to be easily adaptable to other application domains. A portable version of FirstAidMap to be used inside ambulances, endowed with a real-time data updating based on a Global Positioning System (GPS), is under study.

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