Poll Sourcing for Crisis Response

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ABSTRACT

During large scale crisis response operations there is an acute and continuous need to efficiently and quickly allocate a dynamically changing supply of resources. In this paper we are proposing a system, which uses polls to seamlessly discover, request, collect and aggregate information from engaged resource providers using the web or mobile devices. At the same time we aim to integrate information from sources such as sensors deployed on incident sites, publicly available open data, corporate legacy systems or documents stored on remote locations. The overall process of such Poll Sourcing also encompasses reservation and order of suitable resources. We provide a validation scenario concerning reservation of hospital beds during a mass casualty incident.

Keywords

Crowd-sourcing, interoperability, poll-sourcing.

INTRODUCTION

During a large-scale crisis response there is a need to seamlessly retrieve, evaluate and exchange information from many parties and rapidly make an appropriate action based on the processed information. Moreover if the information is structured, validated and geo-located it can provide additional value. The seamless collection, aggregation, analysis and effective presentation of relevant and accurate information in the right time can greatly support crisis response.

Therefore the goal is to design and implement a platform, which will support seamless structured geo-mapped information collection and aggregation from large number of users using the web or mobile devices. The primarily users are first responder agencies but also other organizations being involved in crisis mitigation. Also the proposed system tries to improve communication between the crisis stakeholders since a major gap exists in inter-agency communication as well as in information exchange between the general public and the first responders and vice versa during large scale crisis situations. An additional goal is to enable the enrichment of information by data from additional sources such as sensors deployed on incident sites, publicly available open data, corporate legacy systems or documents stored on remote locations.

STATE OF THE ART

There are already tools being developed to collect and aggregate information from web or from mobile devices. The Open Data Kit (ODK) [1] is an open-source, modular toolkit that enables organizations to build application-specific information services for use in resource-constrained environments. ODK currently provides four tools to this end: Collect, Aggregate, Voice and Build. ODK core tools build on existing open standards and are supported by an open-source community that has contributed additional tools. A later developed ODK2 [2] expands and refines information services. The idea behind the Ushahidi [3, 4] platform was to harness the

benefits of crowd-sourcing information (using a large group of people to report on a story) and facilitate the sharing of information in an environment where rumors and uncertainty were dominant. Ushahidi allows users to submit eyewitness reports during a conflict or disaster by web or SMS; the collected reports are subsequently displayed on a map [5]. Ushahidi claims to be a tool that any person or organisation can use to set up their own way to collect and visualize information. Similarly to the Ushahidi platform there are several systems, which allow mapping (or geo-positioning) and visualization of geo-located information on a map such as [6]. In these systems content generated by users (a so called collective intelligence) provides additional information about crisis in order to enhance the response and recovery phases of mass casualty disasters. Existence of these highly interactive systems was made possible by GeoWeb [7], which merged the Web with geo-spatial technologies and by the Web 2.0. In [8] authors put into a great perspective the development of GeoWeb, both in terms of technologies and applications, against crisis management processes. Another initiative is the Epic project where a technology platform called Tweak the Tweet (TtT) aims to improve methods of public information gathering and dissemination during emergency situations. In [9] authors examine and compare Epic's TtT and Ushahidi. TtT was evaluated to contribute by a method to "filter, automate and direct information from social media sources during a disaster". Ushahidi has proven to be "an effective and widely adoptable platform for displaying geospatially-oriented social media communications". The following challenges were identified in [9]:

- systems such Ushahidi or TtT might contribute to information overload;
- there is a problem with credibility and verification of information;
- need for support of analytical reasoning, geospatial analysis and more advanced situational awareness and mapping;
- need for an effective cartographic representation techniques to ensure the usability of web maps for crises;

In [9] authors conclude that "future research must focus on applications that go beyond basic crowd-sourcing to develop information collections, analytical tools, coordination of communications, and mapping visualization to support all phases of disaster management".

Several systems aim to detect events, identify features, detect the geo-location or identify entities relevant to a crisis from media or social networks [10]. Multiagent systems are also suited to manage emergency scenarios that are very changeable [11]. There are also tools provided as public-cloud services which are available to collect, organize and visualize data, such as Google Forms [12] or WuFoo [13]. These tools allow the definition of forms and aggregation of data into data tables for further processing or visualization - although these tools might be useful they require customization to be incorporated into a crisis response process. In addition to the publicly-available tools the existence of proprietary closed systems must be mentioned which are used primarily by first responders where none or only a very limited interoperability is possible with other agencies or with the public what introduces a number of challenges [14]. Proprietary systems greatly vary from country to country or from agency to agency. This poses a great challenge in terms of systems interoperability, effective communication and seamless information retrieval, evaluation and exchange between agencies but also between the agencies and the general public.

REUIREMENTS ANALYSIS

In [15] user requirements are identified for a collective intelligence emergency response system. First responders in several European countries were consulted in order to identify key requirements that they would expect from an information collection and aggregation platform. These requirements were summarized in scope of the Redirnet [16] project, which deals with data interoperability of first responder's systems in general. The provided requirements analysis was used to design a platform together with conceptual, data and process design in order to address as much requirements and interoperability challenges as possible. Another functional requirement that had to be taken into account is that information source validation and verification is crucial during a crisis response. First responders need to know the origin and credibility of information. Therefore security and trust mechanisms had to be incorporated into the platform by the means of authorization and authentication to individual conceptual elements.

CONCEPT

A concept of Polls is used to manage information in the proposed platform. In this perspective a Poll is a process of smartly collecting and aggregating information using a pre-prepared configuration setup from an explicitly specified group of users or services subscribed to a communication Channel. A Template is a set of

typified fields with constraints organized in steps, which must be provided in order to generate a Poll.

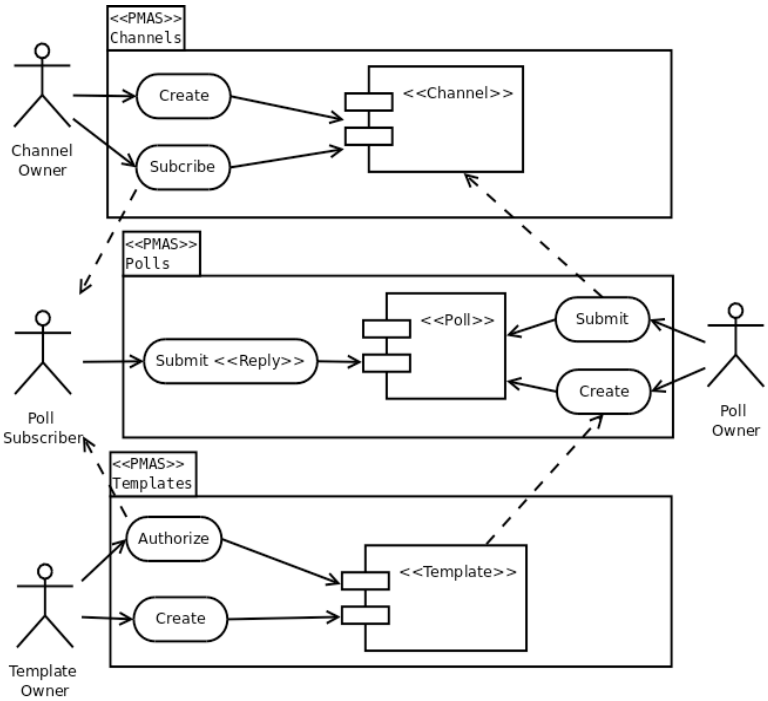

Figure 1. A use case denoting basic relationship between a Poll, Template and a Channel

The basic relation between Polls, Templates and Channels is depicted in Figure 1. There are four major roles in the presented use case: a *Poll Owner* - is an entity (a user or a service), which creates and controls a Poll. A Poll gathers the information on behalf of a Poll Owner. A Poll Owner submits a Poll into a Channel and has rights to manage Poll's operations, runtime and settings. A Poll's behavior can be influenced by its Template settings; a *Poll Member* - is an entity, which is allowed to submit or has submitted a Reply in the respective Poll. A Poll Member is usually a user or a service subscribed to a Channel to which a Poll was submitted. Subscription to a Channel can be enacted by a Channel Owner or by a Poll Member; a *Channel Owner* - is an entity which owns the Channel and has rights to manage channel's operation, subscribers and its settings; and lastly a *Template Owner* - is an entity which defines and manages Templates. A Template Owner authorizes who is allowed to use his Templates for Poll creation.

EXECUTION FLOW

In order to start a Poll it must be first set up - this can be done by executing a wizard-like setup procedure or by explicitly setting the setup values. A Poll can be executed right after the setup procedure is finished or the execution can be planned for a later exact date and time. Polls can be therefore of different types such as one-time, recurrent or continuous. Depending on the type, a Poll can last an explicitly specified time or can run continuously or until a predefined rules are met. When the Poll execution finishes the collected information are aggregated. Based on a Poll Result a report can be compiled or an action can be generated. All or specific predefined subscribers can be informed about the Poll Result. Also one Poll can execute another Poll to deliver required information - this way the Polls can create a simple workflow that can be used to execute a chain of information collection actions. Concretely the Poll life cycle is composed by the execution of the following actions:

1. *Poll Setup* - Polls are created using a setup procedure based on pre-created Poll Templates. A Poll can be executed just after the setup procedure is finished. A Template is composed of a Setup, Poll Questions and Answers and Settings.
2. *Poll Start* - Upon a Poll execution start it is submitted to a Channel. Subsequently all Channel subscribers are notified about a Poll start.

3. *Reply Collection and Aggregation* - Deliver forms to Poll Members via different devices, collect and aggregate replies and combine information by data from services or sensors.
4. *Evaluate Submissions and create a Result* - During Poll execution and upon Poll finish the collected information is aggregated. After the Poll has finished individual Replies are evaluated. The result of this stage is a Result object.
5. *Notify the Result and make an Action* - Based on the Poll Result a report or an action can be generated. All or specific Poll Members can be informed about the Poll execution Result.

COMMUNICATION FLOW AND POLL STATES

In **Figure 2** a sequence diagram demonstrates a typical use of the PMAS service.

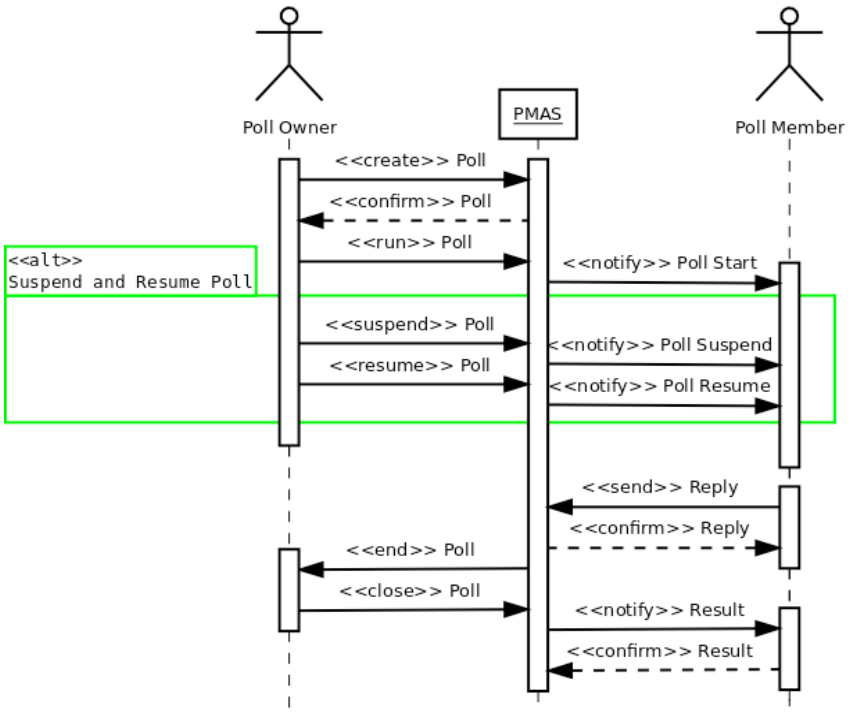

Figure 2. A sequence diagram of communication between a Poll Owner, PMAS and a Poll Member

First a component in the role Poll Owner creates a Poll. PMAS assigns an ID to the Poll. The Poll Owner starts (runs) the Poll. The Poll Member is notified about the Poll start. Alternative sequence is to suspend and resume the Poll execution. During a Poll execution a Poll Member can send a Reply to the PMAS with the ID reference of the Poll. After a Poll is ended it must be closed which includes the creation of a Result. The Poll Member is notified about the Result and sends a confirm notification back to the PMS.

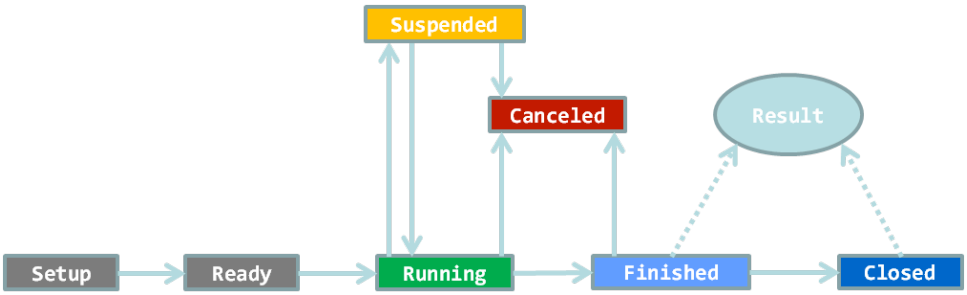

Figure 3. Possible Poll state transitions

During its lifecycle the Poll can be in one of the following states (**Figure 3**):

- *Setup* - state in which the Poll is in while being setup;
- *Ready* - when the setup procedure is finished, the poll is ready to be executed;
- *Running* - a Poll was successfully started and is in the process of collecting responses;
- *Finished* - collection of information was finished and Poll is waiting to be closed;
- *Suspended* - a Poll is suspended for an exact amount of time;
- *Cancelled* - a Poll can be cancelled, no results are delivered;
- *Closed* - evaluation of the collected responses was enacted and the Poll is waiting for evaluation, Result creation and closing.

IMPLEMENTATION AND VALIDATION

A validation scenario was created in scope of the Redirnet project [16] in which information collection takes place from disparate hospitals from legacy databases or from communication devices operated by the hospital staff in charge (**Figure 4**). The requirements for the hospitals are to provide appropriate treatment facilities for the injured persons in a required capacity. Additionally the hospitals must be as close to the incident site as possible. There are Reply Collector Services (RCS) deployed in the vicinity of each hospital. The Poll Management and Aggregation Service (PMAS) collects the replies. The two additional components in **Figure 4** are the Redirnet Semantic Interoperability Services - which provide semantic description of our RCS components and the Redirnet Collaboration Web - which is an user interface for integrating operations of different subsystems. Each involved hospital has to be subscribed to a Channel, which is used to groups hospitals in a related area.

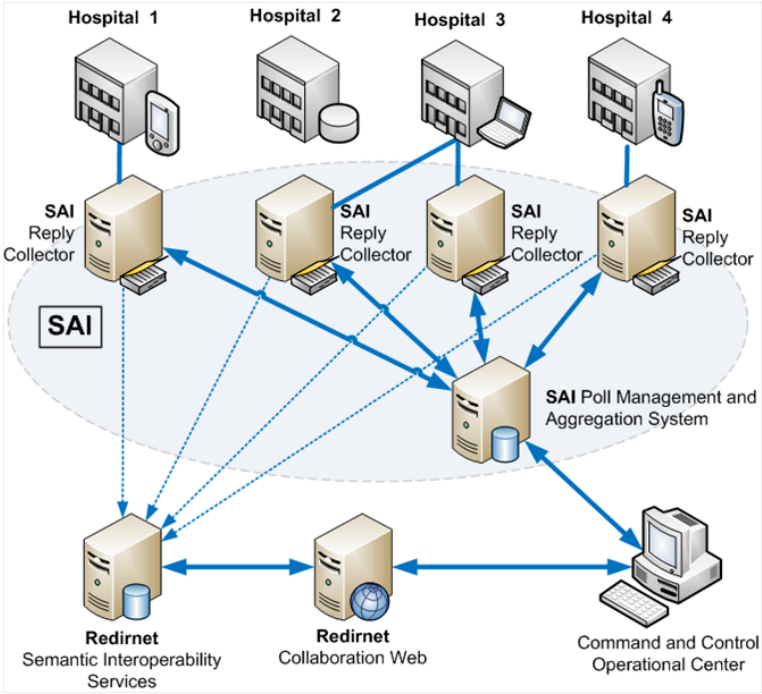

Figure 4. The Validation Architecture

In the case of a crisis situation an operational commander, located in the Command and Control Operational Center, submits a Poll to the selected Channel, which requests hospital capacities from all the channel subscribers. The operational commander uses a pre-prepared Template to submit the Poll. A special wizard process creates a new Poll based on the selected Template. In the first step a Template must be selected from the list of all available templates and also a Poll type and a unique Poll identifier must be selected (**Figure 5**).

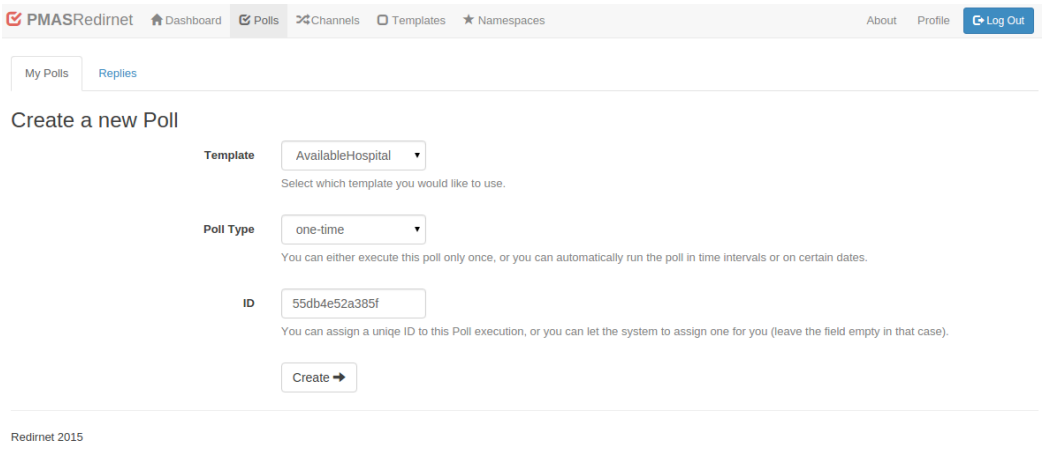

Figure 5. First Step in a Poll creation

The next step is generated based on the pre-created Poll Template. In this case we need to provide the number of injured people, select the geo-location of the incidence and select the Poll start and finish dates and times (**Figure 6**).

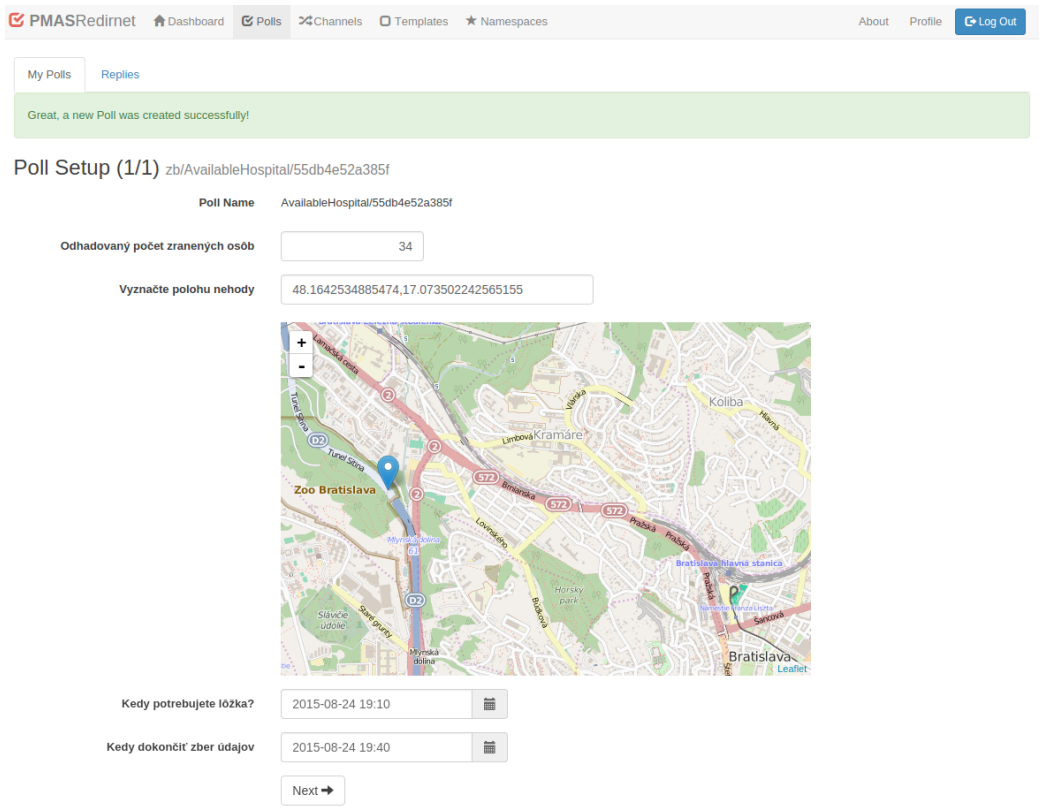

Figure 6. The Poll setup based on the Template object

The last step of the Poll creation is selection of a communication Channel to which the Poll will be submitted. The Poll summary besides a Channel selection comprises also a deadline confirmation and the automatically generated request text specification. After the Poll creation is finished the new Poll instance is displayed in the Poll list and the Poll is ready to be executed (**Figure 7**).

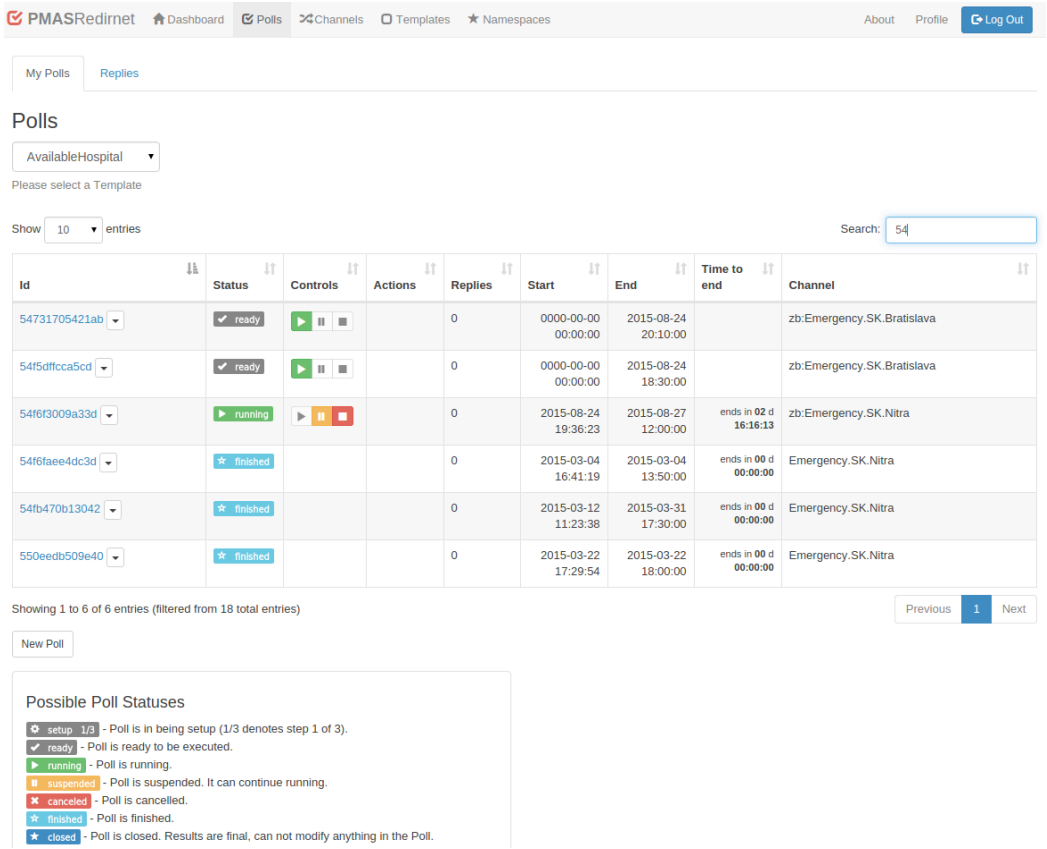

Figure 7. The list of Polls and its states

As a result of the Poll execution each Channel subscriber will receive a request (**Figure 8**).

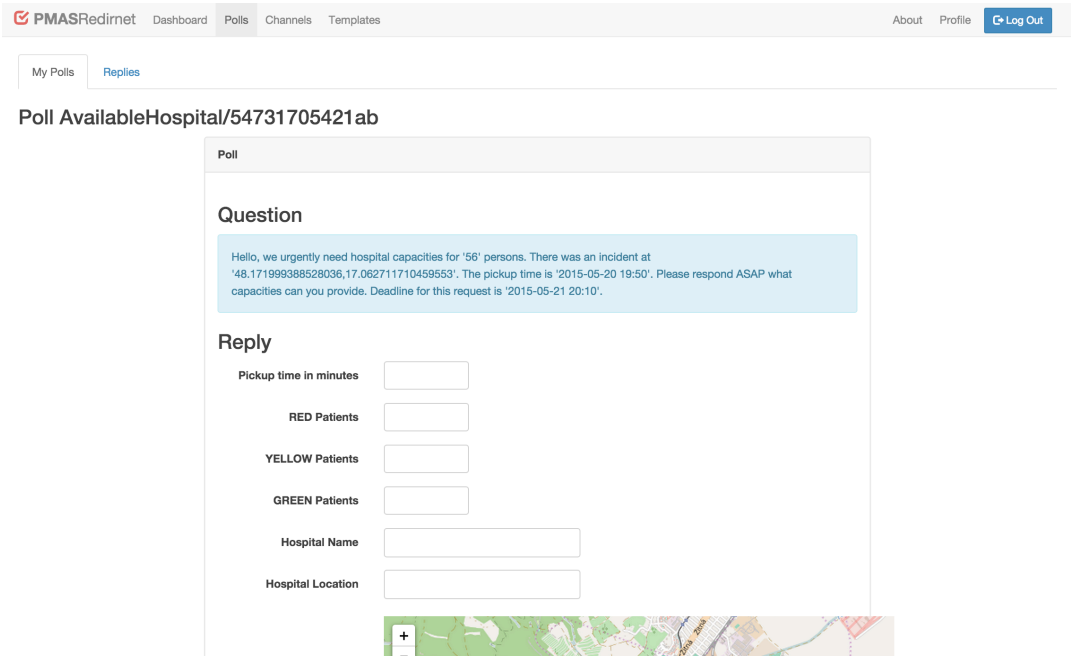

Figure 8. A sample Poll reply form

Every hospital is required to submit a reply in the given Poll by the specified Poll end deadline. Finally the Poll owner summarizes the results of all the received replies and makes a decision about the distribution of patients to individual hospitals according to predefined preferences.

DISCUSSION AND CONCLUSION

There is a large plethora of other possible application uses of Poll sourcing including crowd-sourcing crisis-related information, overcome language or operational discrepancies between emergency responders in a case of a cross-border incidents, awareness for emergency response teams and mass alerts, interactive maps of incident sites, dynamic voting, transportation management, operational plan delivery or resource management in general. The system is being recently developed and is using a distributed cloud-based infrastructure to ensure fail-resilience, trust and reliability. From a scientific point of view there are many challenges to be resolved including: security aspects to protect the privacy of Poll participants, large scale architecture for continuous and fail resilient infrastructure, trust and credibility of collected information, multi-lingual challenges or complexity of dynamic distributed systems for management of continuously streaming data.

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