

# Towards a Crowdsourcing-based Approach to enhance Decision Making in Collaborative Crisis Management

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## ABSTRACT

Managing crises is considered as one of the most complicated organizational and managerial task. Indeed, dealing with such situations calls for many groups from different institutions and organizations to interact and collaborate their efforts in a timely manner to reduce their effects. However, response organizations are challenged by several problems. The urgent need of a shared and mutual situational awareness, information and knowledge about the situation are distributed across time and space and owned by both organizations and people. Additionally, decisions and actions have to be achieved promptly, under stress and time pressure. The contribution outlined in this paper is suggesting a crowdsourcing-based approach for decision making in collaborative crisis management based on the literature requirements. The objective of the approach is to support situational awareness and enhance the decision making process by involving citizens in providing opinions and evaluations of potential response actions.

## Keywords

Crisis management, decision making, crowdsourcing, SBPMN.

## INTRODUCTION

Nowadays, great technological, economical and socio political changes shape our world. This dynamic and complex environment brings the entire society to a range of challenges and exposes it to a complicated climate leading to crisis and disaster situations. A variety of response groups from different organizations need to collaborate and coordinate their efforts in order to contain and handle such events. A process by which, crisis management organizations need to obtain and share a mutual on-the-ground picture of the situation, gather and access critical real-time information, and share response action plans and resources for purpose of making fast and efficient decisions. However, recent crisis events have led respondent organizations to revise their protocols so as to expand the range of contributing actors, by including simple citizens as well as expert operators, to support decision making activities (Ginige et al., 2014). Furthermore, recent studies on crisis and disaster situations have shown that citizens' involvement and participation can lead to better results in term of crisis response. Alongside with the emergence of the web 2.0, scholars and practitioners have made a lot of attention to the concept of "Crowdsourcing", and studies are increasingly converging on this paradigm (Vivacqua and Borges, 2010). Crowdsourcing is considered as a valuable mean used to leverage the community's knowledge and skills, and is seen as a collaboration model enabled by people-centric web technologies to solve individual, organizational, and societal problems using a dynamically formed crowd of interested people who respond to an open call for participation (Pedersen et al., 2013). Moreover, (Brabham, 2008) claims that crowdsourcing is considered as a model capable of aggregating talent, leveraging ingenuity while reducing the costs and time formerly needed to solve problems and make decisions.

In fact, crisis management is about making decisions in a timely fashion under stress and time constraint, with lives and properties at stake. Thus, it depends on efficient sharing and exchange of updated information, and having a shared and mutual situational awareness by the involving stakeholders. Usually, making a decision involves the three phases of the well-known decisional model of Simon: intelligence (information gathering and sharing for problem identification and recognition), design (generating alternative courses of action), and choice (evaluating, prioritizing, and selecting the best course of action). In particular, acting in a collaborative situation may require negotiations and dynamic exchange of suggestions and alternatives between decision participants, which is to a certain extent a time-consuming process. Furthermore, from one hand, Simon's theory of decision making is based on the idea that decision makers did not have a complete knowledge about the situation. On the other hand, developing a crisis management strategy will depend on its unique features. Thus, additional sources of information, knowledge and skills are required to perform better and efficient decisions. Crowdsourcing in this regard, is highlighted as a very relevant mean to cope with these challenges. From the same perspective, (Bonabeau, 2009) highlights the limitations of individual decision makers in solving business problems and raises the question of what if we rely more on others to find those solutions. Moreover, Bonabeau underlines the power of recent advances in technologies and their capacity to harness the collective intelligence on greater scale than ever before. He claims that crowdsourcing, wisdom of the crowds' concepts, social networks, collaborative software, and other web-based tools constitute a shift paradigm in the way that organizations make decision and calls this emerging era: Decision 2.0.

In this work, we try to examine how crowdsourcing can influence the different phases of the decision making process in a collaborative crisis management situation. To this end, the paper is structured as follows: after discussing the literature review, we present and discuss the crowdsourcing-based approach for decision making that relies on Crowds participation for each phase of the process. Thereafter, we use the Social Business Process Model to highlight the collaboration work that exists between both the response organizations and the citizens within a collaborative crisis management situation.

## BACKGROUND

### Collaborative Crisis Management

Collaboration is a dominant characteristic of every crisis management initiative. Indeed, it is widely outlined by the literature that, crisis response management is a collaborative activity which requires a highly cooperation between response organizations to face and recover from the unwanted outcomes of crisis and disasters events. Several cases such as September 11, terrorist attacks and Hurricane Katrina disasters have proven that traditional emergency management tools and methods characterized by centralization and hierarchy-based policies need to be revised (Kapucu and Garayev, 2011). In this trend, The Geographic Information and ICT communities are increasingly involved in the definition and design of methods and techniques that guarantee a better management of the coordination work based on a unique, and shared collaborative platform, which allows collecting information through several sources, query, manage, and analyze this collection in a seamless manner (Ginige et al., 2014).

Due to its complex and dynamic nature, coping with crises requires joint efforts from many collaborating organizations in response to the event (illustrated in figure 1), and presents many challenges in order to make it successful. Indeed, it is quite evident that decision making efficiency, accurate awareness of the situation, and taking advantage of the collective intelligence are very dependent upon the good communication and collaboration between crisis response organizations or teams. By reviewing the literature, we can distinguish three main approaches of communication and information systems for crisis management:

- Emergency Response Information Systems;
- Decision Support Systems;
- and Web 2.0 and Social Networking based solutions.

Especially in large-scale crisis situations, the tendency is remarkably oriented towards web-based systems (Volunteered Geographic information systems, Spatial Decision Support Systems, Crowdsourcing systems) regarding the dispersed nature of respondent teams and the possibility of large public involvement.

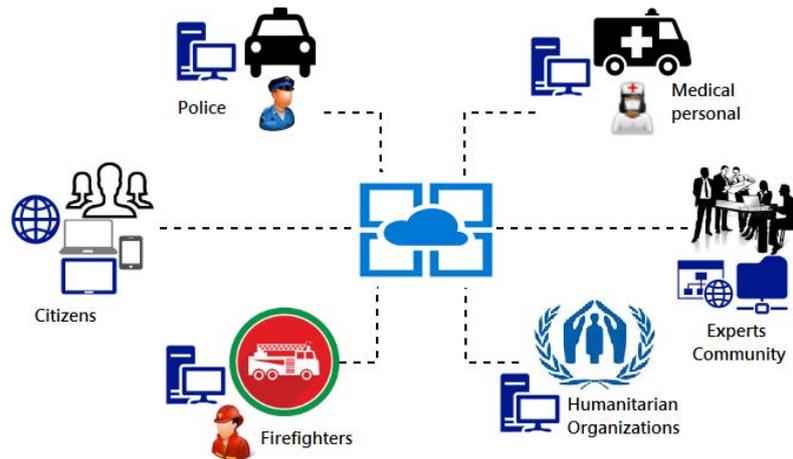


Figure 1: Example of collaborating stakeholders in collaborative crisis management

### Decision Support for Crisis Management

The decision making process during crisis and disaster management has been covered in the literature and studies have highlighted its complexity (Diniz et al., 2005; Ley et al., 2014). In such collaborative and dynamic situations, different collaborators interact with each other and joint their efforts in order to have cooperate and effective actions and making collective decisions. Moreover, it is no longer accepted that decisions are made statically by few centrally located individuals. Regarding its changing nature, a crisis situation entails delegation of decision making to those experts best suited to have authority to make decisions (Turoff et al., 2008). Turoff et al claim that “Deferring to Expertise” is something too often lacking in crisis events. They suggest that having a fully dispersed command and control center, and delegating authority based upon the expertise of the participants for the current requirements, will promote continuous ability to function effectively in face of such events. Moreover, (Othman et al., 2014) stated that crisis management involves collaborative decision making activities often characterized by a high level of complexity involving different sources of knowledge distributed across time, space and people. The knowledge used to make decisions in time of crisis is available in different forms, and can be of different nature (Diniz et al., 2005) as depicted in figure 2.

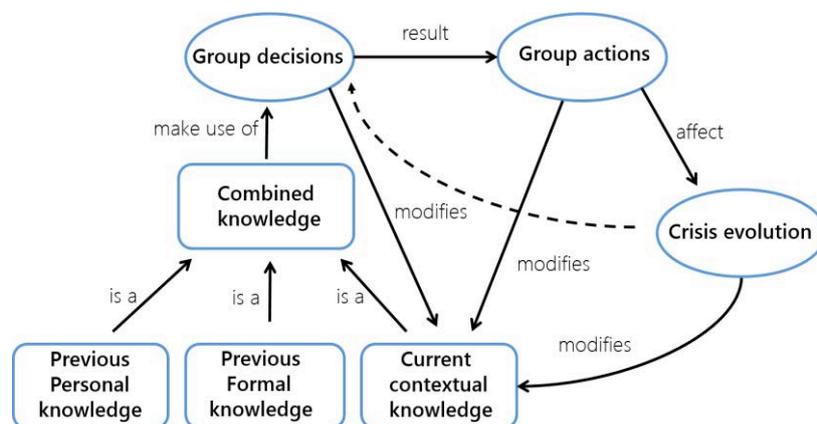


Figure 2: Conceptual map of knowledge support during crisis management (Diniz et al., 2005)

The “*previous personal knowledge*” is embedded in each crisis responder’s mind. The second form consists of any information or knowledge relevant to the decision coming from a reliable source other than the individual’s own mind (local maps, water sources, etc.). This knowledge is usually explicit, does not change during the course of the crisis evolution, and is called “*previous formal knowledge*”. The third type is called “*current contextual knowledge*”, which is generated by the crisis itself or by the response to it. We can distinguish two types of current context: one corresponds to the crisis phase (mitigation, preparedness, response, and recovery), and the other including the actions performed by the crisis response teams.

(Holsaple, 2008) presents a pyramid drawing the relation between the different knowledge states and the decision making process of Simon. The decision making process is considered as encompassing a complete set of knowledge states: data, information, structured information, insight, judgment, and decision. Various

operations can be undertaken to progress from one state to another. For instance, by selecting from data, a processor obtains the next higher knowledge state (i.e., information). From selecting, other operations include analyzing, synthesizing, weighing, and evaluating.

In spite of the collaborative nature of crisis management activities, few studies have treated the aspect of collaborative decision making (Yu and Cai, 2009; Kapucu and Garayev, 2011). This is may be related to the fact that crisis situations require rapid decisions. On the contrary, the negotiations and the dynamic exchange of suggestions and alternatives between decision makers to a certain extent is a time-consuming process and involve mutual situational awareness of the crisis context. To cope with these issues, Geographic Information Systems and Online mapping technologies represent key elements for participatory decision making. In fact, using map-based online discussion can increase both organizations and community awareness, and offer a flexible participatory decision making processes (Kapucu and Garayev, 2011). Furthermore, Geospatial Annotation Systems can provide an effective communication and analysis platform to enrich the dialogues among various stakeholders in spatial decision making processes, which explicitly links participants' discussion contributions with their geographic references in the map (Yu and Cai, 2009).

As can be seen, geographic information systems and online mapping technologies have been considered as powerful tools used to overcome collaborative decision making biases. These challenges will increase proportionally with the number of involved stakeholders having different cultures and protocols. Large public and volunteer communities gain more involvement in the process and additional efforts may be required to find better integration and configurations of these new displayed parameters of the decision making process.

### Crowdsourcing-based Crisis Management

Several crisis and disaster situations such as Haiti earthquake and Japan Tsunami, have shown that crisis affected communities tend to share and update situated information. This geographic information have been of vital relevance for the involved organizations to allocate resources, prepare plans, and prioritize actions for response and relief. However, given its diverse format and large amount, response organizations unfortunately, have a limited staff, resources, and ability to acquire, synthesize and evaluate this geographic information. With the emergence of the web 2.0 and the high advances in information and communication technologies, citizen's participation to the crisis management process have shifted from just providing data and information without processing it (social media tweets, etc.) to more active participation by performing specific tasks (interpret, evaluate, and aggregate geographic information) as illustrated in figure 3. This emerging process is known as "crowdsourcing phenomena".

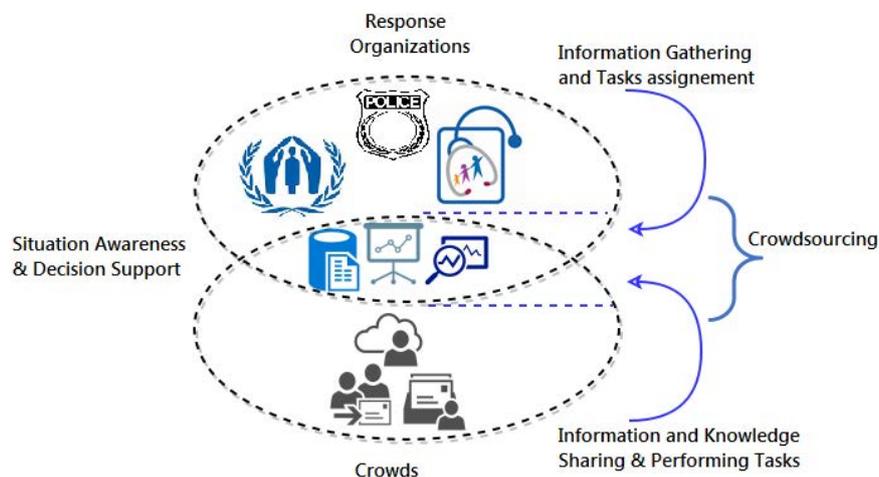


Figure 3: Crowdsourcing support process in collaborative crisis management

Crowdsourcing is considered as a multi-disciplinary domain and many initiatives exist in the literature to clarify such an umbrella term. (Estellés-Arolas and González-Ladrón-De-Guevara, 2012) based on available definitions have tried to synthesize them and give a more exhaustive and consistent one. "Crowdsourcing is a type of participative online activity in which an individual, organization, or company with enough means proposes to a group of individuals of varying knowledge, heterogeneity, and number, via a flexible open call, the voluntary undertaking of a task. The undertaking of the task, of variable complexity and modularity, and in which the crowd should participate bringing their work, money, knowledge and/or experience, always entails mutual benefit".

Beside its great benefits, crowdsourcing implementation presents a panoply of outstanding issues. The trustworthiness and accuracy of the crowdsourced information are the most challenging issues to be considered. Indeed, engaging crowds in performing tasks might require particular knowledge and skills. Therefore, the crowds as a whole have to be “Wise” to some extent. In this regard, (Surowiecki, 2005) calls this particular characteristic “the Wisdom of Crowds”. Moreover, Surowiecki proposes four conditions for crowds to be wise:

- Cognitive diversity, by which involved individuals have different backgrounds, Knowledge, and skills;
- Independence, wherein each contributor’s participation is independent from each other’s;
- Decentralization, through which people are allowed to make their own independent decisions;
- Aggregation, which represents a mechanism for transforming many contributions (opinions or decisions) into a collective one.

Crowdsourcing is a very ambitious area of research, which has attracted a lot of attention from crisis informatics scholars and practitioners during the last decade. So, many initiatives have been conducted by researchers to address different considerations and challenges to be taking into account while implementing the latter, and to extract the best configurations of crowdsourcing for efficient mobilization of volunteers, knowledge/or skills, and available resources in crisis situations. (Liu et al., 2014) based on several vignettes, propose a Framework serving as systematic, problem-driven approach to determine the why, who, what, when, where, and how aspects of a crowdsourcing system. The framework also draws attention to the social, technological, organizational, and policy (STOP) interfaces that need to be designed to manage the articulation work involved with reducing the complexity of coordinating across these key dimensions. (Schimak et al., 2015) present an overview of the crowdsourcing applicability for crisis and disaster management. Thereafter they present several examples of crowdsourcing and crowdtasking at work, discuss key characteristics and challenges of crowdsourcing in crisis management and finally outline a generic methodology and functional architecture for future crisis management crowdtasking tools. Similar to this work, (Poblet et al., 2014) present an overview of technological (online platforms and mobile apps) solutions that are currently applied in the area of emergency management and have in common the use of data generated and/or processed by large numbers of citizens via social media and social networks. The authors distinguish different roles of the crowd based on the type of data being processed and the level of participation involved. Then, they discuss the applicability and association of roles in each phases of the crisis management cycle.

## PROPOSED APPROACH

Crisis events put the response community in a unique environment that requires critical real-time distributed decision making. Making fast and efficient decisions needs an accurate situational awareness picture of the event, and depends on the effective use and coordination of resources, people, and information, where information and knowledge are distributed and owned by both organizations and citizens.

Based on the work done by (Holsaple, 2008) and the framework proposed by (Liu, 2014) presented in the background point 2 and 3, we examine the applicability of the crowdsourcing sub processes to the decision making process in the crisis management context. We delineate the “who, why and how to do it” of Liu’s Framework for each phase of Simon’s decisional model (as shown in figure 4). We include citizens into the decisional process, either by providing information about the crisis or as volunteers performing specific tasks related to information management needs. The crowdsourcing-based approach should enable the participation of both citizens and crisis response organizations, assisting the decision making process of the latter. In this approach, crisis actors can act both as consumers and as providers of information, so information will circulate in a two-way mode. On one hand, citizens provide real-time information about the event in order to exhibit an accurate situational awareness and a shared on the ground picture for the involved response organizations. On the other hand, organizations share their plans and resources to both citizens and the others crisis management organizations to obtain a clear activity awareness of the crisis management community.

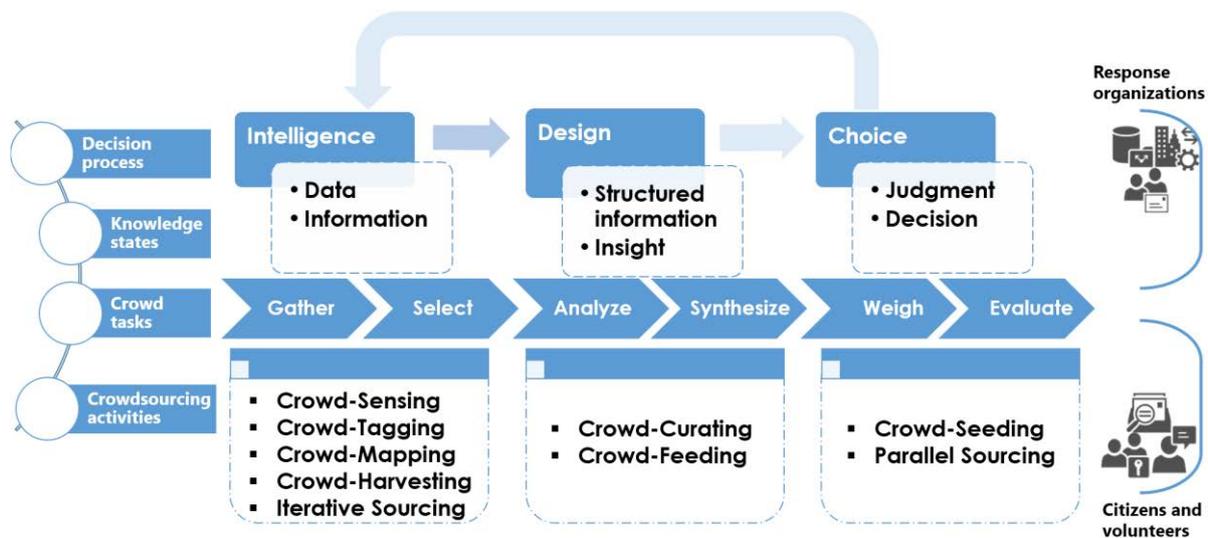


Figure 4: Crowdsourcing-based decision making approach for crisis management

### The Intelligence phase

In this phase, response community seeks for a clear and accurate situational awareness about the affected region, which volunteers can offer through empirical eyewitness reports. Affected populations and Diasporas are relevant actors in this phase. They are directly and immediately involved in gathering data and information related to the crisis place and its impacts. Moreover, they proceed to information selection and sharing based on their local knowledge of their own environment. In other words, citizens tend to gather, select and share information about what they sensed and observed in the crisis field, and this process is known as “Crowd-Sensing”. A process that has been made very easy and extremely fast due to the widespread use of Social networking technologies and mobile devices. However, the collection process may produce a large amount of unstructured data and information, which generates information overload problems. Consequently, crowds have to be involved in categorization and classification of the provided data through “Crowd-Tagging process”. In this regard, situational awareness ontologies may be of potential use in order to overcome confusions of terms regarding the differences in protocols and systems between the different stakeholders. First responders need a general idea or picture about the impacted area, that is, crowds are asked to Geo-locate and Geo-tag (marking features on a map) the crisis or disaster zones using mapping tools (Google earth, Open Street Map, etc). This process may require skilled persons using professional tools like ArcGIS or ordinary participants using tools such as the OSM. The crowdsourcers iteratively improve the work done by previous workers, which facilitate a sequential improvement of the data quality by allowing ongoing participations of different crowds. The very basic participation of the crowd to information management process can be just providing raw data by using phones, tablets, and their social networks (GPS coordinates of the device). This one-way passive contribution is known as the “Crowd-harvesting process”.

### The Design phase

In this phase, we shift from simple data and information to more established and structured information. The Crowds in this case and based on the available information and their own knowledge and skills, proceed to information processing and management for giving insights and proposing possible alternatives in terms of actions. Both Social networks and digital volunteer communities are required for this purpose. In fact, the existing trust between the socially connected crowds affects how one interprets the quality and the reliability of the solutions produced by the crowds. Moreover, social networks tend to bring together a variety of backgrounds and expertise relevant to the crisis. At this stage of the decision process, the ultimate objective of the crowd is to find actionable crisis information and then share it in a meaningful way to key stakeholders, which may require filtering, analyzing, synthesizing, and then exhibiting a curated version of the information to the crisis management stakeholders. For instance, first situational reports provide real-time information used to measure affected population needs, existing resources, shelters, and infrastructure ability. The main objective of the Crowds is to reduce irrelevance and redundancy of information in these documents, analyze demands based on victims’ locations and health conditions, types of supplies, etc. A synthesized report is then sent to the response organizations in order to prioritize the rescue operations, and elaborate a coordinated plan for supplies distribution. Thereafter, the presented information and insights are processed and then shared back to the crowd for more adjustment. This active two-way feedback loop represents the “Crowd-Feeding process”.

### The Choice phase

This phase concerns the evaluation of the proposed solutions and courses of action proposed in the previous stage. Evaluation can be made through voting mechanisms to select the most appropriate alternatives. This form of crowdsourcing involves an active one-way request and only selected members of the crowd can participate to this process. For instance, both diasporas and digital volunteers' community are called for this assessment process to avoid social interference that can be engendered by affected population and social networks. To this end, the parallel sourcing is the most relevant model where participants evaluate the same alternative independently of other's choices. The parallel approach is based on decentralization, which reduces consequently the likelihood of each participant to be influenced narrowly by the work of previous crowds.

In fact, information needs differ for each phases of the crisis management cycle, for different response organizations, and vary for each stage of the decision making process. Moreover, information and knowledge are geographically distributed, with a high degree of diversity and heterogeneity. Additionally, decision makers did not have the ability to locate and process the needed information required for specific tasks by different crisis response teams. In this regard, information filtering, indexing, categorizing, and linking are extremely important to exhibit through an enormous volume of dynamically collected information those that are most relevant to each specific crisis response task. As a result, facing these challenges is certainly going to make a great deal of information management issues. In light of these challenges, crowdsourcing comes as a powerful tool leveraging the collective intelligence of the crowd and the available resources through the intermediary of a dedicated crowdsourcing platform.

To exhibit the coordination work that exists between the response organizations and the involved citizens in the decision making process, as illustrated in fig 5, we use the Social extension of Business Process Model (SBPMN) that aims to define a specific notation for describing Social BPM behaviors (Brambilla et al., 2012). The main objectives of the SBPMN is making the internal decision procedures more visible to the affected stakeholders, assigning an activity to a broader set of contributors, and eliciting opinions that contribute to the decision making process.

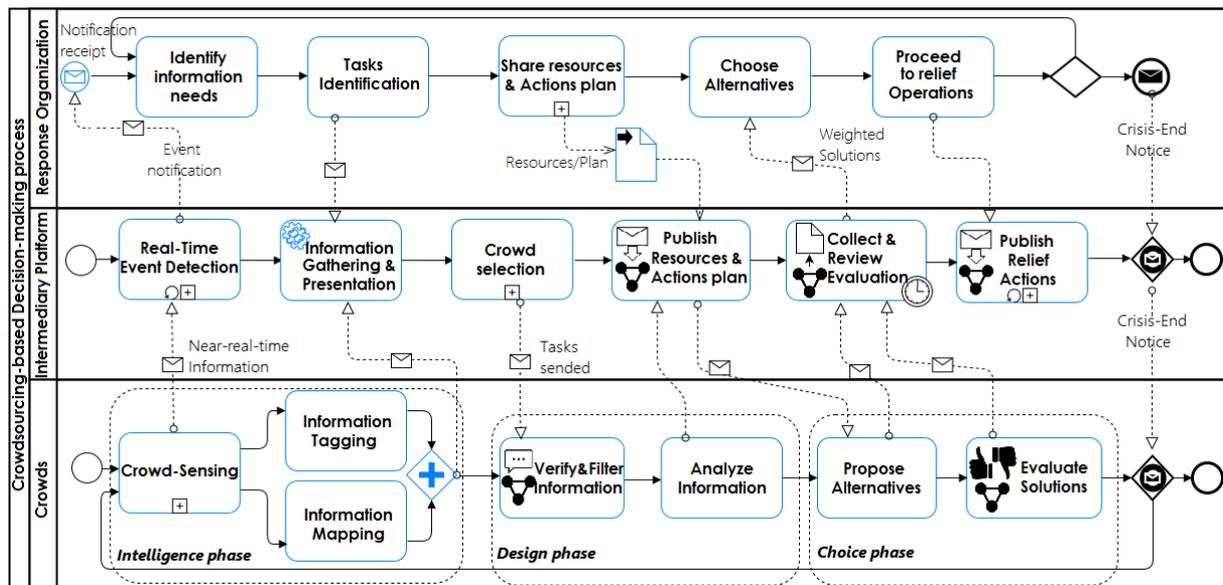


Figure 5: SBPMN model for the Crowdsourcing-based decision making in crisis situations

The crowdsourcing Platform should make use of knowledge discovery algorithms to automatically detect Near-real-time information through their simple use of social media and social networks to report eyewitnesses of the event. In addition to using citizens as human sensors, the Platform may incorporate existing devices sensor networks to the information gathering process. After identifying information needs, crisis management organizations carry out tasks assignment process, which may be performed based on citizens' profiles (crowd selection) using data mining and machine-learning techniques. For instance, Diasporas and affected population are more needed in the information tagging and mapping sub processes. After receiving Synthesized and aggregated information from the crowd, response organizations can share their resources and plans of relief actions for both citizens and the other organizations. In order to get a real-time distributed planning and coordination of response actions, avoid multiple responses to the same request at the same time, and reuse available resources by different organizations in different times. Crisis responders can also share or publish potential alternatives for citizens to have feedbacks and evaluations of these alternatives. The generation of first

plan of actions has to be realized by either internal or external experts to ensure a reliable start. It can be supported by case based reasoning systems, which allow retrieving of past crisis situations based on features similarities, and provide solutions for the new event. Presentation of the collected information, resources, plan of actions and relief operations can be done using visualization and collaborative technologies such as online mapping tools or Geo-collaborative tools. It will enhance the situational awareness picture, guide the efficient coordination and co-creation of courses of action, and facilitate the participatory decision process.

## RELATED WORK

Crisis management stakeholders need effective plans and procedures in place to prepare for, respond to, recover from and mitigate the potential effects of crisis events. A corner stone of these plans is knowing what needs to be known and providing this knowledge to the right person in the right place and at the right time. Unfortunately, not all situational knowledge is immediately available, not all knowledge is coming from the same place, and not one person will be qualified to make all decisions (Othman et al., 2014). Furthermore, over and over again it has been seen that in unexpected problems, decision authority flows down to those closest to the situation in either location or knowledge (Turoff et al., 2008).

One of the first initiatives that have studied the crowdsourcing application for decision making is the work done by (Bonabeau, 2009). In his model, Bonabeau suggests that crowdsourcing based decision making process is composed of two phases: the generation of potential solutions and their evaluation. Thereafter, he tackles the decision making process issues that must be taking into account when calling for crowd's participation. In the generation phase, issues such as social interference (participants tend to follow others ideas and opinions), availability (participants tend to be satisfied with the easy solution), anchoring (generated alternatives are focused on the first one), and stimulation (been influenced by how a solution is presented) are addressed. To handle these issues, he proposes for organizations to consider three general types of approach: outreach, additive aggregation, and self-organization. In the alternatives evaluation phase, the set of alternatives is reduced to a smaller one, which can then be evaluated. This process invokes either the integrity of the crowd or a small part of experts. One way or another, (Rosen, 2011) suggests that Bonabeau's discussed issues are well managed when aligned with Surowiecki's conditions of diversity, independence, and decentralization (Surowiecki, 2005). Furthermore, Rosen claims that the two previous works lack consideration of other factors such as compensation for participants, crowdsourcing quality, and communication with crowdsourcing partners. He suggests that an ongoing dialogue, a give and take, between the crowd and the organizations will certainly improve the quality of the ideas generated. Thus, organizations must balance communicating information to the crowd against maintaining their secrets. Closer to this work, (Chiu et al., 2014) propose a Framework to outline the role of crowdsourcing in each phase of Simon's decision making model:

- *Intelligence phase*: like highlighted previously this step consists of information gathering and sharing for problem identification, so crowdsourcers can be involved in search and discovery activities as well as knowledge discovery and accumulation, giving opinions, and making predictions.
- *Design phase*: in this phase, organizations call for crowd's participation in ideas and alternatives generation, which can be performed by different ways: Soliciting ideas from employees (in house mode) or from customers or other outsiders. Two forms of idea generation are addressed: collaborative which is recommended when dealing with knowledge accumulation activities, and competitive generally used to find solutions to a problem or to improve performance.
- *Choice phase*: Crowds are called for analyzing and evaluating generated alternatives and ideas, they can vote on the proposed solutions and give feedbacks as well.

Chiu et al, then identify potential areas of interest for future research, which include finding a balance between diversity and homogeneity in the crowd, definition of relationships between the crowd and the organizations, tasks assignment to participants, reduction of groupthink and other decision biases in the crowdsourcing process.

(Hosio et al., 2016) examine the possibility of using crowdsourcing or the wisdom of crowd to offer on-the-fly decision support. The presented framework is centered on two aspects of decision support systems: populating the knowledge base and exploiting the populated knowledge base. Participants can contribute to the knowledge base construction by rating options in term of criteria. In the decision support stage, users can manipulate the importance of each proposed criterion using simple sliders, and recommendations are presented to the end-users based on the adjusted criterion and the used decision model.

As can be noticed, Crowdsourcing represents a very powerful mean that have been leveraged to assist decision making activities. Yet it presents many challenging issues in order to make it successful. Surowiecki's

conditions have been considered as a general framework for reflection on these issues in the aforementioned works. A compromise between these conditions is necessary to enhance the decision making efficiency, which will depend on the specific characteristics of each situation.

To the best of our knowledge, available literature addresses the applicability of crowdsourcing in decision making for general and arbitrary problem domains and lacks research that examines in particular the crisis management area.

## CONCLUSION

In time of crises, response organizations operate in a new and unique situation. A situation that requires rapid and optimized information gathering, providing contextual knowledge to right person at the right time in the right place, and making time-critical decisions that translates into crisis relief operations. In such situations, a huge amount of data and information are generated with different types, distributed and owned by both organizations and the affected community. From this variety and large volume of data and information, decision makers need to obtain the most relevant and accurate information, extract actionable information, having better insights about the situations in order to make the right judgments. Such a process necessitates large efforts, a variety of backgrounds and skills under stress and time constraints, which may exceed capabilities of the involved organizations and calls for the contribution of the directly affected population to the response process.

Our contribution outlined in this paper is suggesting a crowdsourcing based approach for active citizens' participation to the different phases of the decision making process to face the multitude of information management challenges. The approach will help response organizations to identify the information needs, be aware of the crisis situation evolution, and provide decision-makers with useful recommendations based on affected volunteers' community propositions and evaluations.

Given its collaborative nature, the idea behind crowdsourcing platforms is to allow a more established collaboration between different involved organizations and the large public. However, in reality, the platforms lack collaboration between the response organizations in term of planning and coordination of relief actions. In this regard, crowdsourcing applications must allow the possibility of integration of collaborative tools into the Crowdsourcing systems to overcome coordination barriers.

In our future work, we intend to propose a crowdsourcing-based architecture system of decision support system for collaborative crisis management situations. This architecture will be founded on: literature requirements of collaborative tools and decision support systems design, Crowdsourcing best configuration and conceptualization, and empirical studies. The point is to examine real scenarios of crisis situations in order to get a practical view point of the challenging issues, and barriers faced by the response community, and to determine and analyze the communication and decision making biases in the course of crisis response actions.

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