Journal of Network and Computer Applications 35 (2012) 189–198

Contents lists available at ScienceDirect

Journal of Network and Computer Applications

journal homepage: www.elsevier.com/locate/jnca

Taking advantage of collective knowledge in emergency response systems

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ARTICLE INFO

Article history:
Received 15 September 2010
Received in revised form
13 January 2011
Accepted 1 March 2011
Available online 29 March 2011

Keywords:
Collective intelligence
Crowdsourcing
Disaster relief
Collective knowledge

ABSTRACT

When large groups work on a theme, they have the potential to produce a lot of useful knowledge, regardless of whether they are acting in a coordinated manner or individually. Spontaneously generated information has received much attention in recent years, as organizations and businesses discover the power of crowds. New technologies, such as blogs, Twitter, wikis, photo sharing, collaborative tagging and social networking sites, enable the creation and dissemination of content in a relatively simple way. As a result, the aggregate body of knowledge is growing at an accelerated rate. Many organizations are looking for ways to harness this power, which is being called collective intelligence. Research has shown that it is possible to obtain high quality results from collectively produced work.

In this paper, we consider the domain of emergency response. Research has shown that individuals respond quickly and massively to emergencies, and that they try to help with the situation. Thus, it seems like a logical step to attempt to harness collective knowledge for emergency management. Disaster relief groups and field command frequently suffer from lack of up to date information, which may be critical in a rapidly evolving situation. Some of this information could be generated by the crowd at large, enabling more effective response to the situation. In this paper, we discuss the possibilities for the introduction of collective knowledge in disaster relief and present architecture and examples of how this could be accomplished.

1. Introduction

With the dissemination of the Internet and new interactive technologies, large numbers of people are now online, and a culture of content production and sharing is taking hold. Many people post on blogs, wikis or Twitter and have an active profile on online social networking sites. The current generation of Internet users has got used to online participation in many different forms.

These large groups of people are sometimes able to generate results above and beyond what a single individual could accomplish (Surowiecky, 2004). One example is Wikipedia, which is completely generated by volunteers and another is Linux, one of the best known open source systems ever written. Harnessing this power to one's advantage is something many organizations have been trying to do. New algorithms and techniques are being investigated to help organizations in this task.

APIs now allow access to predefined content and the creation of ''mashups'', or sites that combine content from different sources. This enables processing and reuse of different data beyond what it was originally intended for. Several applications are being developed that mix different sources and reuse data to achieve diverse objectives (for an example, see iGuide,[1] which mixes data from several different sources). In line with this new trend, many governmental sites are also releasing their data to the public.

Another approach, called crowdsourcing (outsourcing to a crowd), effectively entails giving a task for a crowd to execute, instead of executing it oneself. For instance, developing alternate solutions for a given problem could be done by an expert working alone or by a large set of individuals, given appropriate tools. One example is Amazon's Mechanical Turk,[2] a ''marketplace for work'', where it is possible to crowdsource any type of task. Individuals can post ''task offers'' for anyone in the community to perform, for a small payment (tasks include testing systems, proofing websites, etc.). This is currently being explored by the HCI community, which is trying to determine if it is an effective platform for running evaluations, by providing an application and a link to a

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[1] http://iguide.travel/About.
[2] https://www.mturk.com/mturk/welcome.

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doi:10.1016/j.jnca.2011.03.002

usability survey to be filled for a small payment (Kittur et al., 2008; Heer and Bostock, 2010).

In light of this newfound potential of crowds, we investigate ways in which collective knowledge could be tapped for emergency management. Individuals respond strongly to large emergencies, using their social and technological resources to help manage the emergency situation (Hughes et al., 2008), which makes this a strong candidate domain for the application of collective intelligence techniques.

Emergencies and disasters happen all over the world. Floods, hurricanes, fires and landslides threaten people's lives and must be dealt with in a speedy fashion. Disaster relief teams are heavily trained to deal with adverse situations, but they need information to be able to make appropriate plans and act to resolve the situation. This information could be generated by individuals in or around the site. In fact, much information is already spontaneously generated by these individuals, but it is unstructured and disorganized, and is therefore hard to manipulate.

Our group has a history of working with the Rio de Janeiro Fire Department to develop technology to support them. One frequent problem they face is the lack of information about the area surrounding the location of the emergency. This is one problem that could be tackled by a large group, at different stages of the emergency management process and in different ways.

In this paper, we present an analysis of the applicability of collective knowledge to disaster relief and a general framework and architecture for collective knowledge based emergency management systems, and some examples of its application.

In the next section, we discuss collective intelligence and crowdsourcing, followed by a presentation of the domain of disaster management and the types of problems in this domain (Section 3). Initiatives that bring disaster management and collective intelligence together are presented in Section 4. We follow with Section 5, presenting our take on how collective intelligence could help disaster relief efforts, and present a scenario based on a real problem. We finalize in Section 6 with some considerations on the subject and outline future directions for work.

2. Collective intelligence and crowdsourcing

In recent years, researchers have stated that large groups can perform as well or better than individual experts. Surowiecky (2004) argued that groups with certain characteristics are almost certain to produce useful results, and named this collectively produced intelligent behavior the Wisdom of Crowds. One example he provides is the stock market (the futures market in particular), where traders buy and sell stock according to what they believe the future holds for a company, given the information they have. Prices in these markets are not set by one organization or through a coordinated effort, but by thousands of individuals acting upon their information to achieve what they believe will be the best outcome for themselves. Markets have been shown to be better predictors of future events than expert opinions in some cases (Surowiecky, 2004). Based on this observation, some approaches have been created that use this market approach to elicit information and make predictions; these are usually called information or prediction markets.

With increased online participation, the amount of data available has increased greatly, and it is possible to make use of this data through the application of artificial intelligence and data mining methods (Segaran, 2007; Sunstein, 2006).

Another well known case is the open source initiative. In open source development, several people contribute to one joint effort, frequently generating a solid product. Linux is probably the best known case, but there are many others. Wikipedia is another good example: it is a collectively created encyclopedia. After Wikipedia's success, wikis have been started in several subdomains (travel, dictionaries, books, etc.), proving that the approach is valid in multiple domains. This community construction approach was also used to construct a common sense knowledge based at MIT, which reached in a few months the size of another well known common sense knowledge base, CYC, built the traditional way (Singh, 2002).

Harnessing collective knowledge involves combining knowledge (which may include behaviors, preferences, ideas, etc.) from a group of people to produce novel information or insight (Segaran, 2007). Sunstein (2006) presents four ways in which groups could elicit the information they need:

- through statistical averages of independent contributions;
- through deliberation and reasoned exchange of facts and ideas, to improve on the individual judgments;
- using a pricing system or a market; or
- through voluntary contributions on the Internet, eliciting information from whoever desires to contribute.

The Internet opens up new possibilities for interaction and knowledge construction by large groups of people. This knowledge can be put to use in many situations, including disaster relief.

3. Disaster relief

Aligne (2009) defines crisis as a situation in which there is a break from previous events. A crisis threatens the functioning and values of an individual or community, and there is an urgent need for action despite difficulties. One of the most important characteristics of a crisis is that it is unpredictable and cannot be totally anticipated by scenarios. To resolve a crisis, it is important to reflect and gather information with which to mobilize resources.

We consider the four phases of emergency management shown in Fig. 1, which are related in a cyclic fashion: mitigation, preparedness, response and recovery. Each phase is detailed below.

Mitigation: This phase is carried out well before the occurrence of an adverse event and is repeated after its completion. This step refers to the policies and activities aimed at reducing the vulnerability of a population, or minimizing the harmful effects of future or unavoidable disasters. The phase begins with the identification and assessment of hazards and moves to planning and implementation of long term measures. Among these measures are plans for occupation of land, construction of protective structures such as dykes or water drains, laws and penalties, adoption of better standards and techniques in engineering and allocation of shelters.

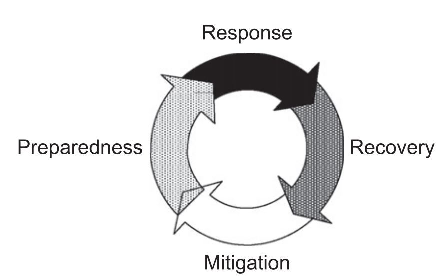

Fig. 1. Emergency management phases. Arrows indicate natural emergency flow and darkness indicates importance of time.