

Beyond the Trustworthy Tweet: A Deeper Understanding of Microblogged Data Use by Disaster Response and Humanitarian Relief Organizations

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ABSTRACT

In this paper we present findings from interviews conducted with representatives from large international disaster response organizations concerning their use of social media data in crisis response. We present findings in which the barriers to use by responding organizations have gone beyond simple discussions of trustworthiness to that of more operational issues rather than mere data quality. We argue that the landscape of the use of microblogged data in crisis response is varied, with pockets of use and acceptance among organizations. We found that microblogged data is useful to responders in situations where information is limited, such as at the beginning of an emergency response effort, and when the risks of ignoring an accurate response outweigh the risks of acting on an incorrect one. In some situations, such as search and rescue operations, microblogged data may never meet the standards of quality required. In others, such as resource and supply management, microblogging data could be useful as long as it is appropriately verified and classified.

Keywords

Humanitarian, Relief, NGO, Disaster, Twitter, Microblogging, Trust.

INTRODUCTION

In 2011 we reported that microblogged data produced by citizens was akin to a food that responding organizations cannot eat (Tapia et al., 2011). While we identified four principal reasons for this disconnect, we primarily focused on the quality of the data produced. We argued that since the responding organizations see the data as untrustworthy, they could not be inserted into the critical decision tree of the organization. In this paper we present the findings from the second round of data collection, conducted a year later. In this round of data collection we find the barriers to use by responding organizations have gone beyond simple discussions of trustworthiness and data quality to that of more operational issues. We present data and findings from research conducted with representatives from twenty-one humanitarian and response organizations collected in 2011. We argue that while data quality continues to be a barrier, what is far more important to organizational use is the serving of this data at the appropriate time, in the appropriate form to the appropriate person and the appropriate level of confidence.

BACKGROUND: THE USE AND BARRIERS TO USE OF MICROBLOGGED DATA IN HUMANITARIAN ACTION

Much has been written concerning the value of using messaging and microblogged data from crowds of non-professional participants during disasters. Often referred to as “microblogging”, the practice of average citizens reporting on activities “on-the-ground” during a disaster is seen as increasingly valuable (Palen and Vieweg, 2008; Palen, Vieweg, Liu, & Hughes, 2009; Sutton, Palen, and Shklovski, 2008; Terpstra, 2012; Vieweg, Palen,

Liu, Hughes, and Sutton, 2008). Data produced through microblogging is seen by the decision makers of emergency response teams as ubiquitous, rapid and accessible (Vieweg, 2010), and it is believed to empower average citizens to become more situationally aware during disasters and to coordinate to help themselves (Palen, Vieweg, and Anderson, 2010). In disasters, which occurred recently in developed environments, average citizens offered ground-level information describing the local specifics of the crisis, keeping outsiders informed about the reality on the ground.

Currently, there are numerous extant challenges to the use of citizen observers, namely, issues of reliability, quantification of performance, deception, focus of attention, and effective translation of reported observations/inferences. Temporally, the problem arises at the stage when emergency responders and relief organizations begin engaging their organizational mechanisms to respond to the crises in question (Munro, 2011). For decades, these organizations have operated with a centralized command structure, standard operating procedures, and internal vetting standards to ascertain appropriate responses to disasters. While not optimized to current expectations of speed, efficiency and knowledge, these mechanisms have been successful at bringing rescue, relief and recovery to millions (Walton et al., 2011). A central aspect of these organizational mechanisms is complete control over the internal flow of information concerning the crisis from source to organizational decision maker respectively. This ensures accuracy, security, legitimacy, and eventually, trust between the organization and information source. Despite a tremendous amount of research in the area, no mechanisms have been employed for harvesting microblogged data from the public in such a manner that facilitates organizational decisions. Additionally, expectations of utilizing such information are hampered by network and access problems in both developed and developing countries (Jennex, 2012).

However, part of the issue, the idea that Twitter data flow is inefficient, may be both a perception and adoption problem. As Walton et al. showed in their research on speed in humanitarian logistics, the perception of “speed” is a subjective experience between both relief provider and those they seek to help (2011). Lack of control over communication may lead decision makers to perceive that logistics are slow, and lack of communication from relief organizations make the local affected population experience a perception of slowness as well (Walton et al., 2011). While relief organizations prefer to receive information in a standardized format that makes sense to them, the public has shown that the Twitter environment is not easily tamed, especially during crisis events (Alakkad et al., 2012; Mazmanian, 2013). This suggests that relief organizations that more fully immerse themselves in the Twitter environment feel a better sense of control over the flow of information, and conversely, increased communication back to the local affected public through Twitter, increases public perception of speed, even if the same relief organization does not yet utilize the medium in their internal decision trees. If the perception of trust is hampered by the adoption of Twitter as technology (Morris et al., 2012; Thomson et al., 2012), increased familiarity will go a long way in increasing trust in Twitter as an information source until such time that technology on behalf of the emergency management world catches up in the processing of information gleaned from the environment.

THE GOOD ENOUGH PRINCIPLE IN HUMANITARIAN ACTION

If Twitter were guaranteed to lead to optimal decision-making, the use of unverified data from unvetted persons would not feel like an insurmountable challenge it has been described (Tapia et al., 2011). As Palen et al. (2010) contend, crisis responders never have perfect knowledge of any given crisis, as crises, by definition, are scenarios where conditions hinge on extreme instability. In order to have all available data, an event must exist in a bounded universe. Disasters and other crisis, however, are complex by nature, with many moving parts, and are not at all capable of being finite, evolving hour by hour. Thus, satisficing, or the “good enough” principle in decision making should also apply to the technology employed in disaster scenarios (Granger-Happ, 2008). No automated tool is going to magically account for all the unknown variables of a situation, but the tools employed can maximize the assessment of the variables known and help establish a certain level of trust.

As research in humanitarian disaster response teams has shown, even with the incorporation of all possible data, optimal decision making is difficult to achieve (Muhren and Walle, 2010), thus, the advent of Twitter should not be seen as a cure-all. The basic mechanism for overcoming the optimization issue is the establishment of trust, which is the expectation of a reliable or good outcome despite vulnerabilities and imperfect knowledge (Alpern, 1997); that people have the ability, benevolence, and integrity to report good information. Trust begins by first being predisposed to trust, or in this case, trusting that the local affected community has everyone’s best interest in mind when contributing information, and by trusting the mechanism by which that information is delivered (Thomson et al., 2012; Valenzuela et al., 2009). Despite research showing the rise of the altruistic community in the local affected population during crisis events (Quarantelli, 1999), there is still an expectation that people and information should be vetted. This is not an unreasonable argument as Twitter has shown a high propensity for rumor-mongering and proliferating false information (Mendoza et al., 2010a; Morris et al., 2012), and that the anonymous nature of many who tweet are correlated to higher incidences of contributing information from less

than credible sources (Thomson et al., 2012). Also, considering the altruistic community, Twitter has been shown to have an organic and persistent self-correcting mechanism working on behalf of the Twitter community to challenge false information (Mendoza et al., 2010b). Another way of looking at this problem of data quality is to view crowd filters in the form of re-tweets as an ad-hoc recommendation system for good information (Starbird and Muzny, 2012). However, reasonable trust in good intentions and information provided by the local affected public does not translate into information presented in a usable form.

With the differences in culture, operations, and operational language among the various disaster response organizations, it is not reasonable to assume that information gleaned from Twitter, even if true and accurate, can easily be assimilated into operational decision making. Accepting data from Twitter as a viable source of information is possibly a basic technology adoption issue. During the Fukushima earthquake in Japan 2010, Twitter was regarded as the least credible news source (Thomson et al., 2012); however, research has shown that as people increase their actual usage of social media, they tend to view it as a more credible source (Morris et al., 2012; Valenzuela et al., 2009). Supposing that both Twitter and the community contributing to it are deemed trustworthy, receiving that information in a usable form remains a challenge (Tapia et al., 2011). As FEMA director Craig Fugate contends: "In government, we're infamous for wanting to standardize and template and format to make it easy. But that's not how we're seeing social media. The public defines how they're going to use it." (Mazmanian, 2013). Overcoming the barrier of processing information may be the biggest factor in establishing trust.

Natural language processing and geo-locating have made great leaps in extracting, processing and classifying Twitter feeds, but in real-time situations and to a reasonable degree of accuracy, sufficient efficiency has not yet been achieved. Most research in this area has been performed post-hoc, and the most important aspects of any intelligence received, intelligence that is actionable and precisely geo-located, has not yet been achieved and is also complicated by translation and nuance of understanding language (McClendon and Robinson, 2012; Munro, 2011). Even if the Twitter environment is accepted and the vetting of people contributing to it is set-aside, absolute trust in the content provided is still difficult to achieve due to processing and filtering issues. Until such a time that comprehensive automation is achieved, it may be best to shift the perspective, as Palen et al. recommended, from "accuracy" to "helpfulness" (2010). A decision maker may not necessarily act upon information gleaned from Twitter, but that is not to say that they simultaneously cannot be aware of or view the information as useful in some way.

RESEARCH DESIGN

In 2010, in response to the devastating earthquake in Haiti, a new collaborative research group was initiated at Penn State entitled EMERSE: Enhanced Messaging for the Emergency Response Sector. This research group drew in both computer scientists and social scientists seeking to use their research skills to help. The purpose of the research group was to find mechanisms to make citizen-originated data useful to emergency responders and humanitarian agencies. In 2011 (Tapia et al., 2011) data and findings were presented from the first round of qualitative interviews conducted with the members of the organization NetHope.

NetHope is an information technology collaboration of 37 leading international nongovernmental organizations (NGOs) representing more than \$30 billion (U.S.) of humanitarian development, emergency response, and conservation programs serving millions of beneficiaries in more than 180 countries. Through member collaboration and by facilitating public-private partnerships with major technology companies, foundations, and individuals, NetHope helps members use their technology investments to better serve people in the most remote areas of the world. Currently NetHope membership consists of international NGOs including: CARE, Catholic Relief Services, International Federation of Red Cross and Red Crescent Societies, Mercy Corps, Oxfam, Save the Children, and World Vision, among others.

The Board of Directors of NetHope facilitated the data-gathering phase for this research. We conducted twenty-one in-depth qualitative interviews with a single representative of each participating member organization. Semi-structured interviews were the main emphasis since they allow the researcher to guide the interviewee to cover specific topics, but were flexible enough to pursue avenues of inquiry as they arise (Berg, 1989). The person interviewed typically was the chief information officer, or other highly ranked technologist for the organization. However, most importantly, in this round of interviews we also sought out participants who were actively involved in their organizations Emergency Response Division. We learned from our first round of interviews that Humanitarian Response organizations were highly siloed and the information use by one division may not mirror that of another. Each research subject spoke for the organization as a whole, often with significant administrative, technological and operational experience. While we interviewed representatives from the same organizations as the first round of data collection, we did not interview the same people in 80% of the cases.

Each interview lasted between 60 and 75 minutes and was audio taped and transcribed. The transcribed interviews were analyzed using analytic induction, a mixture of deductive and inductive approaches (Epstein and Martin, 2004). First, we developed a set of codes based on insights we had gained from the larger research, previous studies on social media and microblogging use in humanitarian relief and emergency response, and the interview core questions. These codes were used deductively. During the coding process, we also identified codes that emerged from the data. This inductive approach is a typical approach to qualitative data analysis. For these codes, the process was iterative and cyclical, drawing from a framework developed by Seidel (1998).

To ensure a high level of credibility and trustworthiness of our data and analysis we employed several techniques (Gall et al., 1996). First, we used multiple techniques to ensure the chain of evidence regarding our data and analysis. We employed both a strategy of long-term involvement in that this project was a small part of a larger project in which we spent four years collecting data from the same organizations. We believe that this helped to correct for situation specific influences. We also connected a coding check in which multiple researchers independently coded the data and checked for differences. We believe that if the raw data and the codes were shared the logical relationship between research questions, research procedures, raw data, and results should be such that a reasonably prudent person would arrive at the same or similar conclusions.

FINDINGS

In our first round of data collection in 2010 our respondents stated clearly that the data were not trustworthy so they could not be used for any purpose by the responding organization. This blanket statement was retracted in the second round of interviews in 2011 and replaced with a more nuanced response.

A Varied Landscape of Data Quality

When asked about standards of data quality upon which decisions were made more than three-quarters of the respondents smiled or laughed. This was typically followed by a statement that can be summarized to be akin to ‘we use the best data available, but in most cases high quality data is never available.’ Most of these respondents simultaneously expressed three things: regret that better data was not typically available, acceptance that this condition was part of the nature of their work, and understanding that despite the lack of perfect data hundreds of emergencies had been responded to successfully, millions of lives had been saved and regions had been reconstructed.

Several respondents discussed the challenges of getting information from local sources at the onset of a disaster, particularly when an organization did not have members already stationed at a location. One subject said, “At the onset of an event sometimes we have no one on the ground...and even if we do sometimes they are incapacitated or can’t get word to us. It can take several hours to get communications up and regular.” Since an organization may not have a trusted source already geographically situated in the place where a crisis occurs, this necessitates the need to cultivate outside, un-vetted sources. Many respondents said their organization uses whatever information is available at the time until they can get a team on location to perform a traditional assessment.

Even once an organization has representatives on location, some respondents said they still look to local or third party sources for additional information to establish a sense of context. As another subject explained, “*We get reports from our own team on the ground, but we also get information from volunteers and from other teams. Sometimes there are just people in the region from a mission or program who can share information about the situation. We can build a pretty good picture out of all that.*” Accepting information from various outside sources enables organizations to establish a preliminary overview or an assessment of the emergency as it stands even though that information has not been thoroughly vetted.

This is not to suggest that responders have not previously gathered information from ad hoc sources during a crisis event, in fact, it happens as a matter of course during most emergencies, but as one responder describes, there is a certain expectation of how and where the information may be coming from and a system as to how the responder will seek information, and in that familiarity of process, there is an immediate sense of trust instilled in the information received:

“We are already getting stuff from everywhere. Yeah, we get official reports from our own reps on the ground, but we also get a lot more stuff that eventually makes it into the sit reps [situational reports for high level decision makers]. If we can, we call people we know who are there, whether they work for us or not. If we can’t call, we text. I’ll call people there who are in the government, working for other NGOs in the military, ours or theirs, doesn’t matter. If they are there then we’ll try to get to them. ...sometimes I don’t even know them, but somebody does.

The urgency of emergency response can make information collection secondary to actual response efforts. One subject commented, *“We never know everything, ever...It doesn't matter. We still have to do it.”*

The interviews show that the field of humanitarian and emergency response already makes decisions based on imperfect data, often from second-hand sources. The inherently chaotic nature of any disaster limits responders' ability to both gather and assess the quality of information from traditional sources. Microblogged data can serve as an additional source of information, but is still being presented in an unfamiliar way, which leads to any information contained within a microblogged message to become suspect simply based on that information being presented in a new format unfamiliar to emergency responders.

A Varied Landscape of Decisions

Overall, all participants expressed that their information needs changed as the disaster environment changed. At the onset of a disaster they expressed that they needed to understand the context and the scope of an emergency, including the size and location of the affected population and the extent of the damage to basic support infrastructure. Later, they need information about specific gaps in the availability of goods, services and other forms of aid. Still later they need information about operational coordination, i.e. who is responding with what and where. Lastly, they expressed that they need regular updates on the security situation, the impact of the intervention, the status of the affected population, and constant inter-organizational coordination of information:

“Look, there is no one-size-fits-all approach here. What I need at 8:00 from the initial flash report is not what I need at 16:00... Sure we have standard assessment forms and flash reports, but they are never everything we need. We always ask for more from the people who are there.”

The information needs of responders do not just change as a disaster progresses, but also from disaster to disaster. In the words of a respondent, *“Every disaster is different. That's why this job is so hard. What we did in Haiti is completely different than what was needed in Aceh and in Turkey. Each one is a new game.”*

Subjects also discussed a shift from a high quantity of easy decisions early on, to fewer, but more difficult questions as they shifted from emergency response to disaster recovery. As an interviewee discussed, *“When it starts I have to make a hundred decisions in one day. Should I activate? How bad is it? Whether to deploy? Who to send? What to send?...I have to make these decisions fast...”* This sentiment was echoed in another subject's comment, *“Sometimes I have to make easy decisions like whether to get the ball rolling—are we going to respond. Once we are going then I have to make harder decisions about what is really needed and who, what and where I should send our people and goods. Logistics questions are tougher.”*

Microblogged data's value as an information source is not a constant, and would vary as a disaster response develops.

Data Type Influences the Required Level of Data Quality

Nearly all respondents stated that the requirements for data quality and trustworthiness were variable depending on the type of question asked by the responding organization.

Two thirds of our subjects stated that in the case of initial awareness of a disaster they would accept a low or unknown threshold for data quality in exchange for real time knowledge. One subject stated, *“I often look to social media to know whether I should activate and deploy. If I see a bunch of people tweeting about an earthquake in Japan you bet I am going to get out of bed. If I see enough people [tweeting] then it gets me up and I make some calls.”*

Others emphasized the speed at which microblogged data is created and propagated claiming that Twitter was “an excellent early warning system” that allowed them to “know immediately if something is going on” Often, the subjects stated they first heard about a disaster as it was happening via social media personally or via a colleague who was scanning their own feeds. This prompted the subject to seek additional information and to make a decision to deploy or not.

More than half of the subjects stated that they looked to social media data during the first few days after a disaster for contextual data. Contextual data did not have the same level of data quality needs as other forms of data. The subjects said that often the data they received from official emergency assessments and reports left them with more questions than answers. They expressed that they often combined multiples sources of information to gain a complete picture of a growing emergency situation. The subjects used data from microblogged sources to more fully flesh out descriptions of the emergency context to guide their response. Because the microblogged data was often an accompaniment to more formal sources the standards for the level of trustworthiness of the data were also low. As a respondent recalled, *“We had to go in and set up the*

communications and we needed to know what kind of power was still operational. You know cell towers too, we heard about how bad it was from a text."

The additional context afforded by microblogged data also allowed for early response to enter a disaster area with an idea of the situation on the ground:

"Everything is unknown. Up in the air. We used to have to send in guys half blind...We will have one guy doing the first assessment and calling it in, but it's never enough. You never really know until you get there. If you can get some more from some other staff, you know, informally, then it can help."

At times, even major issues can be discovered from microblogged data sources. One subject stated, "When we went to Indonesia last year there was a big problem with the water. We found out about it first via Twitter before they [NGO leaders] told us." The subjects felt that they received official assessments from standard procedures but that social media data gave them "a feel for what was really going on down there."

Around half of the subjects stated that they would listen to microblogged data from any source, regardless of veracity, if it spoke of a security threat to NGO field workers, supplies or camps. In addition, if these data were compounded by numbers of tweets sharing similar information on the threat the humanitarian responders would act to seek out additional information and take additional precautions. A respondent gave an example of this kind of security threat, *"If a bunch of people are saying that there are guys with guns on the Rue de whatever, then we are gonna check it out."* Later on saying, *"Sometimes it's like a prank call or something. Just some kids messing with us. But do you really want to take that chance? At least we get some warning if it is a real thing."*

Several subjects stated that there were some types of questions that required a very high level of confidence in which microblogged data could not yet be used as a key input. The subjects stated that during the search and rescue phase data from microblogged sources had the potential to both save and lose lives. One subject told the story,

"What would happen if after a disaster people seeking for loved ones in piles of rubble heard that when someone sent a text or tweet about hearing life signs from a loved one, the search and rescue team came running. Every single one of them would then send a text or tweet in hope that someone would come running, in hope, even if there were no signs of life...The entire process for finding living people in the rubble would be uprooted and those that might have been saved using the old search methods may now be left to die. On the other hand, texts have helped find people in Haiti. There just has to be a way of vetting these. Lives are on the line."

According to subjects, resources for search and rescue operations are limited during disaster relief scenarios, and current methods are already efficient at finding and rescuing victims. As the subject above said, many of the reports sent of trapped victims are not sent based on concrete information but are a last attempt for someone to save a loved one. This does not mean however, that people cannot be found and saved based on microblogged data. These reports should have the lowest priority in response, only considered after traditional methods have been exhausted.

Other subjects said that many of the operational decisions about how many people to send, what goods to send and the best routes to use were decisions that required a very high level of accuracy that microblogged data was not able to provide. Subjects found that in most cases decisions had to be made about sending items that would save lives, like water, medicine and food and mistakes made by faulty inputs could not be tolerated.

Networks of Responders Cross Organizational Boundaries

In our first round of data collection in 2010 the subjects mostly responded to our inquiries based on microblogged data that were produced by citizen bystanders to the disaster and populations effected by the disaster. These producers of data were seen as strangers and faceless and removed from the humanitarian community. One year later the subjects of this research changed how they spoke about the producers of the data to include members of their own extended social network. While they recognized that their personal and organizational networks did not cover every corner of the earth, and that inputs from affected populations were still the gold standard, many had come to rely on inputs from a widely dispersed network for operational inputs.

All of our subjects stated that they believed that much of their personal social network was already producing trustworthy and actionable data. They stated that while their network could not provide all data necessary regarding a disaster, it served as a powerful informal source of information about the response and the conditions during a disaster. One subject said, *"During the Japan quake I found out how things were from a couple of people I know in Japan... I learned who was being sent."* Another subject expanded on how microblogged data helped them understand the scope of response in an area, *"Twitter helps a lot. I know where*

people are, who is deploying...I can get a handle of who is where. That is really good.”

Having this information about other organizations is valuable both in efficiency of response and identifying gaps in response efforts. A subject commented, “...so I know that [another NGO] is already there and [a friend who works for this other NGO] is saying how things are. Now I know more about what we’re getting into. I heard about the airport being a mess first from [a friend who works for this other NGO]. I don’t think we would have gotten on those boats if we didn’t know about the airport first. It saved us tons of time and headaches.”

All of our subjects stated that they followed members of the humanitarian community via social media, including Twitter and Facebook. The subjects explained that they each had a patchwork of different sources of microblogged data including official accounts managed by public relations and communications divisions of response organizations, unofficial and informal vocal blogs of employees of these organizations, employees of various organizations in different missions across the globe, unofficial and informal vocal blogs of humanitarian focused or interested individuals and family and friends. A subject stated, “I follow a lot of people. Some are just old friends but a lot are people I know from work. When something is going on, they know.” Subjects said they were willing to trust microblogged data if the source was a member of another humanitarian response network. As one subject said, “Sometimes I just feel like those people know more than us, faster. It would be stupid not to listen.”

Due to the high turnover rate for employees working in the humanitarian field, our subjects also explained that since they had changed jobs so often and moved so often that they had friends they followed from many organizations all over the world. Another subject said, “Yeah, I work for [large NGO] but I used to work for the UN and I know all those guys there and when they started tweeting about the flooding I knew we were going too.” Another subject commented that, “Half the people I follow I used to work with. I used to work in the [country] mission and I know everybody who still works there. We still have some projects together. I know what is going on back there.” This frequent movement of employees helps create inter-organizational links, facilitated by social networks.

As social networks have become more and more ubiquitous, it is understandable that the members of emergency response organizations have adopted them for personal use. Networks such as Twitter and Facebook have allowed the connections between these members to persist even after they are no longer working together. While these connections could be leveraged through more traditional means, the broadcast nature of microblogged data greatly reduces the effort required to gather information in this manner.

Reliance on Volunteer and Technical Communities

In about a third of our subjects the respondents mentioned that they had already used or were planning to use secondary microblogged data, in other words, Twitter data that had been collected on a large scale and processed by outside groups other than their own member organization. In this case they expressed more trust of the volunteer and technical communities than the original data. Communities that were mentioned were Ushahidi, Crisis Mappers, The Stand by Task Force and the Digital Humanitarian Network. Each of these communities used a combination of crowd-sourcing and computational techniques to collect relevant microblogged data, process and categorize the data, and plot the data on a map for the responding organization. One subject put the willingness in terms of convenience, saying, “We are a small shop compared to some of the other members, we are never going to have the resources to learn how to process twitter and texts. But, if Ushahidi makes maps of what’s going on in the affected region, we are going to use them. They are better than anything we can make or get.”

Subjects also discussed how valuable sharing processed data could be. As one subject stated, “When we were in Libya the Stand by Task Force was activated and got us unbelievable maps. We had no UN office in Libya and needed info fast. The Task Force got over 200 people to process Facebook and Twitter and Flickr sites to plot what was going on. We got useable maps in just a few days.”

While not every subject mentioned trusting a third party to process microblogged data so it could serve as input into their decision-making process, many did. They transferred expertise and trust to outside their organization, to trusting volunteers processing the data rather than the data itself.

DISCUSSION: A CHANGING LANDSCAPE

At the end of Tapia, et. al. (Tapia et al. 2011) we offered three potential paths toward increased microblogged data use by humanitarian organizations: the creation of a bounded microblogging environment, the use of microblogged data for its ambient or contextual value, and the development computational solutions to

automating trustworthiness standards within large datasets. At the time we considered these to be three discreet options, with the larger community favoring the third, most technical choice. However, after our second round of data collection, we see these three potential paths playing out in some fashion and often overlapping. Our second round of data collection has shown us that the informational needs of humanitarian organizations responding to a crisis are varied, and the standards for the quality of that data also varies.

In 2011 we proposed the development of a bounded microblogging environment where membership was limited to only those vetted by a particular organization or community. A responding organization would sacrifice some of the value of bystander microblogging during disasters in order to achieve a more trustworthy data stream. We argued that bounded environments undermined the value of the system. By vetting membership, the sources remain official and make the on-the-ground nature of ordinary Twitter users superfluous. The power of the medium lies in the fact that people, out of their own volition, make localized observations and that organizations could harness that multitude of data. The bounded environment argument neutralized that.

However, what we have found is that a form of bounded environment has in part grown organically. Employees and volunteers already working in the relief sector have become active social media users, perhaps overcoming a technology adoption problem as previously suggested. They friend and follow colleagues and coworkers all over the world who form a semi-bounded environment, from which, data about disasters and their response flows. The participants in these networks are friends and friends of friends and largely trusted, sharing the same cultural understandings of humanitarian response and practice. This is largely informal, organic and crosses organizational borders and hierarchies. This means that trust is not merely a singular interaction between two people, or two groups, or even a decision maker to another group, but a chain; whereby trust is extended, transitioned, and extended again with the result being that if one is contributing information to this bounded group, that they were first admitted to group on a basis of being capable of providing trustworthy information in the first place, even if they do not have existing relationships with all members of the group. The data produced in these groups serves as supplemental input to decisions made by organizational responders.

In 2011 we also proposed a second option of using microblogged data as ambient or contextual data to enrich the information provided to the responding organization at the time of disaster. The data would not need to hold up high standards of verification since it would serve only as a side bar to traditional inputs. At the time we predicted that the more formal the information gathering and transmission process is, the greater the loss of contextual information, and the greater value of a side stream of contextual data. Since then we have seen that this form of ambient awareness system is already operational and growing in conjunction with existing decision trees. As humanitarian responders have more fully engaged with social media they have created their own forms of broad, asynchronous, lightweight and always-on communication systems around issues and regions that interest them.

Lastly, in 2011 we suggested as a third option which would include computational models that would process large amounts of citizen produced data and serve it to responders in forms that could be inputs to their data stream. We initially thought that organizations would gather microblogged data arising from geographically significant areas, apply some analytical techniques that automate classifications and use the classified information to enhance the data gathered in more traditional ways. We saw these models as the most promising in that they will use data produced by citizen observers, are scalable, and will manage the needs for data authenticity and security, as demanded by the responding organizations. We now see that the creation of these systems is far more difficult than first imagined and the task has been taken up not by the responding organizations, but by volunteer and technical communities that have grown up since the Haiti response to fill this computational need.

CONCLUSION

In the sections above we have shown that the landscape of the use of microblogged data in crisis response is varied, with pockets of use and acceptance among organizations. In our earlier work we framed the problem of non-use of microblogged data by responding organizations as a purely data quality issue. With time, we have come to understand that data quality is only one aspect of the overall assimilation of microblogged data into the process of decision-making within organizations.

Microblogged data is also useful to responders in situations where information is limited, such as at the beginning of an emergency response effort, and when the risks of ignoring an accurate response outweigh the risks of acting on an incorrect one. The technical implications of the research findings in this paper suggest that not all data derived from social media need be vetted but that it does require rigorous and nuanced sorting and categorization. Sorting and categorizing data as merely contextual from data that is potentially action-worthy is the first step. From there, identifying actionable intelligence derived from data, translating that data into an understandable and useable form, and then vetting the source and data content naturally follows. In some

situations, such as search and rescue operations, microblogged data may never meet the standards of quality required. In others, such as resource and supply management, microblogging data could be useful as long as it is appropriately verified and classified. Organizations should formally identify these pairings of situation and the required quality of microblogged data, sharing standards with Volunteer and Technical communities so that they can contribute the appropriate kind of data to the appropriate kind of decision.

This organic network of humanitarian microblogging users could serve as a middle ground between traditional data sources and unfiltered microblogging data. The non-competitive nature of the goals of humanitarian response organizations is ideal for fostering an environment for inter-organizational information sharing. We should encourage these organizations' employees to friend and follow each other and become regular users of social media. Having an informal, everyday knowledge of what other humanitarian workers are doing could lead to better organizational efficiency and co-ordination of response and recovery efforts.

It is common practice in the business world for organizations to rely on third parties for information verification and analysis, reducing their financial burden. Similarly, humanitarian organizations can shift some of the burden of establishing microblogged data's trustworthiness and usefulness to outside volunteer organizations. Closer relationships between these should be encouraged. Ensuring that organizations such as Ushahidi that specialize in processing microblogged data are producing reliable data could also help encourage humanitarian response organizations to use these sources.

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