

Communication Media Use in Emergency Response Management

Sherri L. Condon
The MITRE Corporation
scondon@mitre.org

Jason R. Robinson
The MITRE Corporation
g753412698@gmail.com

ABSTRACT

The communications of emergency response managers were tracked during simulated catastrophic events at a university campus in the Washington, D.C. region. Local, state, and federal response managers interacted with each other and with students using a variety of communication media in order to investigate the utility of new communication channels for emergency response management. Students and emergency managers interacted using a Twitter-like platform and a portal built with Ushahidi crowd-sourcing software. The emergency managers also used a chat interface that included private instant messaging, telephone, and the county's existing emergency web portal. Their media use was analyzed along with the functions of their communications, and the patterns that emerged are described and quantified.

Keywords

social media, information and communication technology, emergency response

INTRODUCTION

Online media have greatly expanded the ways that emergency managers can communicate with each other and with the citizens they serve. Many emergency response communities are actively exploring the potential of new media for their practices, but researchers note that some public information officers "are still unsure how to adapt social media to emergency response structure and procedure" (Hughes and Palen, 2012) and that agencies like FEMA tend to rely on "the one-way dissemination model of media usage" associated with traditional broadcast media (Latonero and Shklovski, 2011). Hughes, St. Denis, Palen and Anderson (2014) found that few police and fire departments used social media to communicate with the public during Hurricane Sandy.

These concerns motivated the Citizens' Emergency Response Portal System (CERPS) Simulation Experiment (SIMEX), which simulated an Emergency Operations Center (EOC) during catastrophic events on a university campus near Washington, D.C. Although the simulation could not possibly reproduce the environment of a genuine crisis, the CERPS SIMEX provided emergency managers with an opportunity to learn about emergency operations in which citizens participate in information sharing and to consider how policies and procedures might incorporate new communication technologies.

The analyses reported here focus on the patterns of use that emerged as EOC participants interacted in a novel communication environment. The results cannot be expected to predict behavior in other crisis management contexts, but the study begins to address two gaps that have surfaced in research on the use of social media during emergencies. First, the research tends to examine one social media type such as Twitter so that there is a need to understand the roles different media may play in crisis events (National Consortium, 2012). Second, research has focused primarily on the communications of affected communities, but there are also functions for social media to serve in the communications of emergency managers and responders.

A primary function of emergency management is communication, and the CERPS SIMEX made it possible to examine the use of 6 communication media by EOC managers. Records of all online communications were analyzed in order to investigate media use by emergency managers in the simulated EOC. The frequency of messages in each medium is examined, and the functions of messages are analyzed to reveal patterns of media use according to message type. The quantitative results are supplemented by observations of the communication behaviors and by comments from participants in surveys and after action reviews.

Approved for Public Release; Distribution Unlimited 13-2935. © 2013 The MITRE Corporation. All Rights Reserved. The views expressed are those of the author and do not reflect the official policy or position of any public agencies or governments.

RELATED WORK

Research about the use of social media in emergency management ranges from assessments of the utility of social media for emergency management (Gao, Barbier and Goolsby, 2011) to case studies of media use in disasters (Vieweg, Palen, Liu, Hughes and Sutton, 2008; Wu, Wu and Wang, 2009). A significant portion of these studies has focused on the use of online media for situation awareness in crisis situations and on tools to facilitate emergency managers' utilization of "social sensors" for situation awareness (Vieweg, Hughes, Starbird and Palen, 2010; Sakaki, Okazaki and Matsuo, 2010).

Research examining social and technological aspects of emergency and crisis response has been called *crisis informatics* (Hiltz and Gonzalez, 2012; Palen and Liu, 2007; Vieweg et al., 2010). These studies document increasing reliance on communications networks enabled by social media during disaster events. Hughes and Palen (2009) present evidence of Twitter used more frequently for "information broadcasting and brokerage" when significant events affect many people. In a study of a popular Chinese discussion forum following the Sichuan earthquake, Wu et al. (2009) found that information-related messages were the most frequent contributions and were also read more frequently, especially posts that gathered and integrated information from multiple sources. This result highlights the value of information sharing observed in other studies and the potential for social media to foster a "collective intelligence" (Hiltz and Turoff, 1978; Vieweg et al., 2008).

Additional studies suggest that a few individuals tend to emerge as active "information hubs," serving as information brokers and as the sources of information cascades (Hui, Tyshchuk, Wallace, Magdon-Ismaïl and Goldberg, 2012; Palen and Liu, 2007). Active users with a history of frequent contributions can serve as trusted sources of information in contexts such as crisis events where accuracy is a priority. The validity of crowd-sourced information is a significant issue for use of social media in emergency events, and several studies have investigated the reliability of Twitter as an information source and automatically detecting deceptive tweets (Castillo, Mendoza and Poblete, 2011; Hiltz and Gonzalez, 2012).

Another community-based source of information-sharing is the Ushahidi crowd-sourcing platform, which is an interactive mapping and content management system designed for reporting and updating crisis incidents. During the aftermath of the earthquake in Haiti, the software mapped power outages, contaminated water, and requests for food, water, shelter and medicine (Yates and Paquette, 2010). In a typical deployment, volunteers participate in mapping, verification, translation and quality assessments of reports submitted by contributors.

A majority of research on social media for emergency response has focused on the emerging patterns of use in communities affected by crisis events. In contrast, there are few empirical studies of the ways that emergency managers are using information and communication technology (ICT) to interact among themselves and with the public. However, emergency managers are increasingly incorporating social media and other technology in their communications, and they are sharing their experiences in white papers, wikis, and blogs such as the resources that are gathered on the "Social Media 4 Emergency Management" website (Social Media, 2013). They are participating in forums such as the 2011 Social Media + Emergency Management Camp, which was organized by the CrisisCommons Social Media in Emergency Management Initiative (Wardell and Su, 2011).

Emergency managers are also experimenting with the concept of a Virtual Operations Support Team (VOST), in which a virtual team of trusted volunteers manages and monitors social media communications in support of emergency incident response (St. Denis, Hughes and Palen, 2012). In addition, emergency managers and researchers are identifying the issues and changes that need to be addressed in order to realize the benefits of social media and ICT for emergency management (Hughes and Palen, 2012; Palen and Liu, 2007; Wardell and Su, 2011). Finally, emergency managers and researchers are participating in exercises like the CERPS SIMEX, which provides a rare opportunity to observe the patterns of media use that emerged when emergency operations managers explored a set of new communication technologies.

CERPS SIMEX OVERVIEW

In the CERPS SIMEX, students and emergency operations managers interacted using social media under simulated catastrophic conditions. In the virtual simulation, protests on the campus deteriorated into explosions and hazmat exposure, which escalated the emergency above the local level to involve State, National Guard, and Federal resources. Citizen involvement in the emergency response was represented by university student volunteers who were recruited to participate in the study. Students, whose identities remained anonymous, and EOC managers accessed a website that provided links to a Twitter-like capability developed from an open source platform (StatusNet, 2013) and referred to as "Chirp" during the experiment. (A virtual private network was used to avoid confusing the public.) The website also linked to an emergency reporting system based on the Ushahidi platform, which was called the Citizen Emergency Response Portal (CERP).

Students could also navigate to the Simulated Sensory Environment (SSE) (Emergency, 2013), which provided multimedia content about the simulated events on the campus. They were able to consult videos and descriptions in SSE, and then communicate about them as if they had experienced the events that were portrayed. The SSE was constantly updated as simulated events were injected. For example, each day began with video and descriptions of protesters demonstrating against a speaker who had been invited to address a campus event, and then 15 - 30 minutes later, a description of an explosion at a campus building was added. Later, images of responders, people with guns or suspicious abandoned backpacks were added. A simulated news network (SNN) also produced chirp messages with links to video broadcasts and announcements such as shelter locations.

Emergency managers and personnel from a law enforcement agency interacted in a simulated Emergency Operations Center (EOC) in MITRE's National Security Experimentation Laboratory (NSEL) (MITRE, 2013). The NSEL provides a state-of-the art command center capable of integrating simulated inputs and experimental technology with logging functions that record participants' access to applications and communications. Other participants were gathered in a "white cell" to generate simulated input to the EOC such as simulated reports from the campus incident commander to the EOC commander. For example, reports of 911 calls, hazmat warnings, and plume analyses were injected via phone calls to the EOC or using other communication media (see below). Each day of the experiment was reset to pre-emergency conditions, and similar, but not identical, scenarios were injected for 5-6 hours each day. The simulated times of the scenarios also varied in order to allow appropriate periods of time to pass for events such as the arrival of National Guard or Federal resources. For example, when participants returned from lunch, 4-10 hours may have passed in the simulation.

DATA COLLECTION

The CERPS SIMEX focused on citizen-EOC collaborations via social media, but our analyses view these interactions in the larger context of EOC communications. Table 1 summarizes the types of communication media for which data were collected, the types of users who had access to each channel, and the number of communications recorded for each channel. NSEL resources include a VOIP telephone system and a chat capability with a function that permits private messaging between two people in the chat room. Another channel for EOC communications was a county emergency management portal¹. The county EOC portal is similar to the Ushahidi-based CERP: both provide a basic functionality for users to produce, post, and read incident reports plus a mapping capability that links reports to their locations on a map. Both also permit users to comment on or update reports, and both are monitored by moderators who screen report submissions before they are posted.

EOC personnel were also able to use the Twitter-like Chirp application and a MITRE-developed suite of tools for searching and analyzing the messages produced in Chirp. Like Twitter, Chirp messages have a maximum 140 characters and are associated with their senders' user names in a virtual public forum. All Twitter functionality, such as the use of hashtags to associate message content with specific topics, is available in Chirp. For all of the media, logs recorded time stamps, senders, and addressees (when relevant), and for all except the VOIP, records included the content of the messages. Another important communication channel is not documented in the report: the participant who served as the Incident Commander communicated with the EOC commander by radio as if he were on the scene at the campus, and there are no records of those radio communications. Similarly, there are no records of face-to-face communications that took place in the EOC.

COMMUNICATION MEDIA USE BY EOC MANAGERS

The CERPS SIMEX has provided a unique opportunity to observe how emergency managers communicate in EOCs during catastrophic events. The EOC managers engaged in some new behaviors that were facilitated by the new communications capabilities in the SIMEX, but they still needed to produce all of the communications

Medium	Description	Users	Messages
VOIP	VOIP telephony	EOC and simulation managers	766
EOC chat	Chat room	EOC and simulation managers	408
Private chat	Instant message	EOC and simulation managers	359
County Web	Web report portal	EOC and simulation managers	1048
CERP	Web report portal	EOC and simulation managers, students	532
Chirp	Twitter analogue	EOC and simulation managers, students	6702

Table 1. Communication Media for Emergency Managers in CERPS SIMEX

¹ Due to agreements with participating agencies, we are unable to provide specific agency names or identifiers.

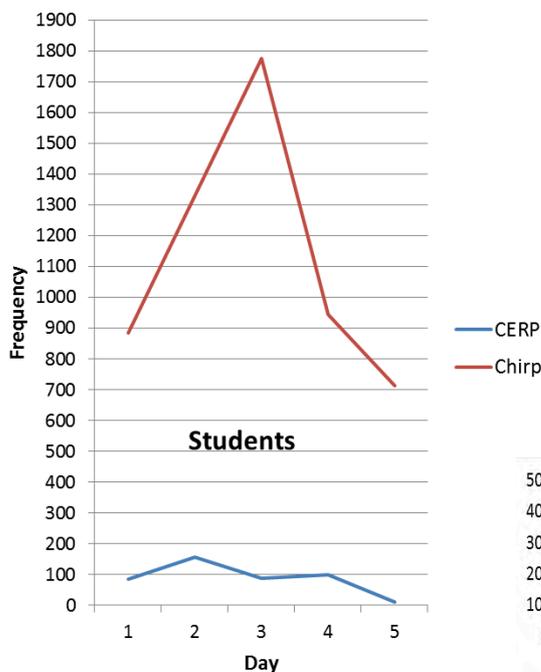
that are normally associated with the EOC. Consequently, the CERPS SIMEX data permit a rich and refined description of communications in the EOC. The CERPS SIMEX was greatly enhanced by the high quality of EOC managers who participated in the event. This study focused on the following EOC managers:

1. The EOC Commander, abbreviated as *EOC* in the charts, an official in the county's emergency management department
2. The City Cell Commander/Public Information Officer abbreviated as *CITY* in the charts
3. The County Public Information Officer, abbreviated as *COUNTY* in the charts
4. The State cell Commander from the state's emergency management department, abbreviated as *STATE-EM* in the charts
5. A State Public Information Officer, abbreviated as *STATE-PR* in the charts
6. An official representing a State responding agency, abbreviated as *STATE-RA* in the charts
7. An official representing a Federal responding agency, abbreviated as *FED* in the charts
8. The campus cell commander, abbreviated as *CAMPUS* in the charts, an official in the campus security department
9. The simulated news network representing broadcast media, abbreviated as *SNN* in the charts
10. Several managers and public information officers from a law enforcement agency participated in the EOC, and the communications from all of these participants are combined and abbreviated as *LAW* in the charts.

Figure 1 provides an overview of communication media use by the students and EOC users for each of the 5 days of the CERPS SIMEX. The thousands of Chirps produced by the 140+ students overwhelm the messages in other media and by other participants. Nevertheless, the key EOC users produced almost 600 communications on Day 1 and 700 on Day 3. Use of all communication media is lower on Day 4 due to technical difficulties, and use of the media used by the students (Chirp and CERP) is lower on Day 5 due a request from the Secret Service to suspend student communications in the morning during a visit by President Obama to the campus.

Figure 1 shows that both students and EOC managers more frequently produced shorter Chirp messages rather than CERP reports, which required greater effort to post. Yet participants (mostly students) posted over 100 reports and comments to CERP each day that it was available, and references to CERP messages in the content of the chirps show that participants were consulting CERP reports and sharing information from them. Our access to logs of the messages that participants produced is limited because we could not observe the frequencies with which participants read the messages that others posted.

The county emergency operations Web portal and the telephone (VOIP) were familiar to the EOC managers and can provide reference points to compare their use of the less familiar communication media. Though they posted only 2 more messages on Chirp than on the county Web portal (*CTYWeb*) on the first day, by the second day EOC managers were posting about twice as many messages on Chirp, and the difference persisted until the last day when Chirp was not available in the morning. This trend suggests that EOC managers became increasingly comfortable with the medium and more cognizant of its value.



With the exception of radio communications to the EOC from the Incident Commander who simulated reports from the campus, telephones were the primary medium used by the white cell to simulate reports to the EOC managers. Consequently, VOIP use was consistent throughout the experiment. EOC chat, which was a new medium for EOC managers, was also used relatively consistently and with nearly the same frequency as VOIP: EOC managers produced 394 VOIP calls and 388 EOC chat messages during the 5 days. Although EOC chat was not used as frequently as the county as the county emergency Web portal (710 total posts) or Chirp (1026 total), the fact that it was used as frequently

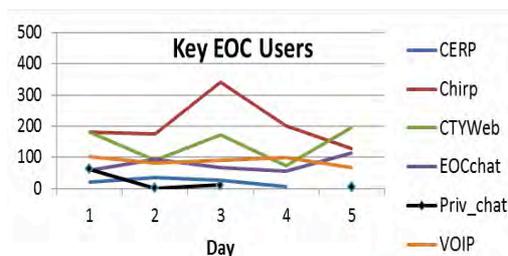


Figure 1: Messages in Each Medium by Students (left) and Key EOC Users (right) for Each Day of the Experiment

as the telephone suggests that the EOC managers adapted quickly to the medium and found at least as many reasons to use it as they did for the telephone.

In contrast, the private chat medium (*Priv_chat*), which was also a new medium for EOC managers, was used only occasionally. We can speculate that one reason private messages were not used frequently was that the EOC managers had other options available for dyadic communication. They could use the telephone or simply talk face-to-face. A significant factor in this media use is likely to be the functions that EOC communications served in each medium, which are analyzed below.

Figure 2 shows the communication media use of key EOC participants for the first 3 days of the SIMEX, showing how the relative usage changed as they became more familiar with the technology. However, some participant roles cannot be compared across the days because different people took on those roles on different days. The participant roles that were filled by different people were the city cell manager (CITY), the county Public Information Officer (COUNTY) and the law enforcement team (LAW).

The campus commander initially took advantage of most of the media available, but his use of Chirp increased from 36% to almost 60% of his communications by Day 3. He also used CERP more than any of the other EOC managers, and together Chirp and CERP were the media he used for 68% of his communications on Day 3. He clearly found the media used by the students to be the most effective means of achieving his goal to preserve the safety of the students and campus. In contrast, the EOC Commander worked in tandem with the participants in the county public information role. The latter communicated with students on Chirp, while the Commander's communications were directed to other emergency managers on the Web portal, by telephone, and on the radio.

The county and state public information officers were the second and third most frequent users of Chirp respectively, and both were using Chirp almost exclusively by Day 3. During the 5 day experiment, the participants in the county public information role used Chirp for 75% of their communications, and the state public information officer used Chirp for 72% of her communications. She also became the second most frequent user of the CERP portal in the EOC. Clearly, an important factor in media use is the EOC manager's role: participants whose function is communication with the public employed the media used by the students.

The state emergency management liaison and the law enforcement team took advantage of most communication media available to them. The law enforcement team actively used all media except CERP. The Simulated Network News (not shown in Figure 2) used Chirp exclusively to post links to their simulated news videos. The lower frequencies of messages produced by the state and federal responding agency liaisons reflect the fact that those agencies are not engaged until the emergency has escalated and emergency declarations are issued at the state and national levels. The federal liaison was also concerned about federal government restrictions on monitoring citizens' communications, but eventually he decided to experiment with the media. Policy concerns such as privacy and liability were raised by EOC managers throughout the experiment.

EOC COMMUNICATION FUNCTIONS

Analysis of the content of EOC communications allows us to observe the functions of messages in the different media. An annotation scheme was developed to be applicable to a variety of communication contexts and to identify content types that are significant to the participants who produced the messages. Focusing on meta-

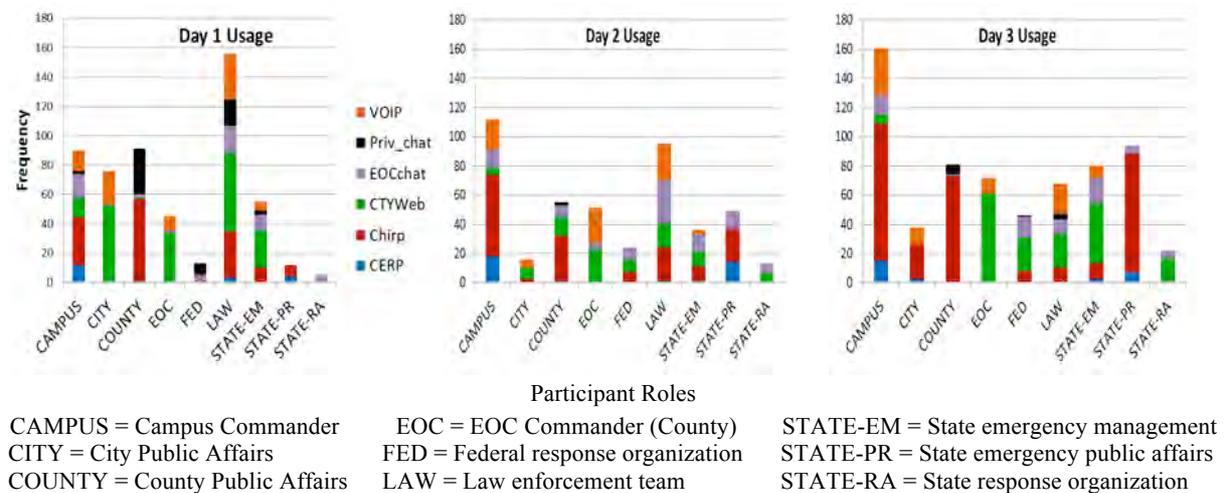


Figure 2: Message Frequencies of Key EOC Participants in Each Medium

Proceedings of the 11th International ISCRAM Conference – University Park, Pennsylvania, USA, May 2014
 S.R. Hiltz, M.S. Pfaff, L. Plotnick, and P.C. Shih, eds.

communication satisfies these goals and also provides a link to other studies of meta-communication in decision making interactions (Condon and Cech 2001, 2007) and military coordination (Condon and Miller, 2003).

Meta-communication is communication about communication that indicates how an interaction should be understood (Dewulf, Gray, Putnam, Lewicki, Aarts, Bouwen. and van Woerkum, 2009). Meta-communication can be verbal or non-verbal, such as when winks, facial expressions or gestures indicate that a speaker is joking or being sarcastic. In this study, we focus on verbal meta-communication, which occurs when speakers or writers use terms that refer explicitly to their communications or to the communications of others. For example, when the Campus Commander chirps, "All university students and employees are reminded to remain off campus roadways to allow emergency vehicle access," he explicitly describes his communication as reminding.

Often, the content of the meta-communication can be communicated without the extra explicit language. The example message could have been formulated as "All university students and employees: remain off campus roadways to allow emergency vehicle access" or "All university students and employees should remain off campus roadways to allow emergency vehicle access." The fact that the commander used the extra explicit language, making sure that the request was interpreted as intended, suggests that he considered the communication significant enough to warrant the additional effort and explicitness. Consequently, by tracking meta-communication, we focus on the messages that the participants themselves marked as significant.

Figure 3 lists six types of meta-communication annotated by the first author. Funding did not permit a second annotator, which would allow us to compute inter-annotator agreement, but the author is an experienced annotator of dialogue and meta-communication (Condon and Cech, 1995; 2001). The meta-communication functions are based on Condon and Cech (2001; 2007). Figure 3 provides examples highlighting the explicit references to communications in red font. (Square brackets [] replace identifiable names that are redacted.)

In **communication directives**, the sender directs the receiver to produce a specified communication or to produce a communication in a specific way. This type of meta-communication is typically directed to the students to guide their interactions with the emergency providers, such as providing a phone number for victims to call if they feel ill. **Reports of communications** are messages in which the sender describes a communication that has previously been communicated, such as reporting that the governor has issued a State Declaration of Emergency. The messages annotated as **Other Explicit Communication** are primarily two types. The most frequent type is messages that direct the students, such as telling them to shelter in place. These are meta-communications when the messages describe themselves like the example discussed above (*All university students and employees are reminded to remain off campus roadways to allow emergency vehicle access*). The other type is messages that evaluate another communication such as *Thanks for the update*.

Task management occurs when EOC managers confer about communications they will produce to perform the task of responding to the emergency. These messages include discussion about which organization will provide information (*You can refer all those inquiries to us*), how information will be released (*Please don't share that with media*), whether notifications have been made (*Has this been posted to RITIS?*), and messages such as *Let*

<p>Communication Directive: requests a specific communication or method of communication</p> <ul style="list-style-type: none"> – <i>use hashtag #suspicious to report any suspicious activity you see</i> (Campus Cmdr on Chirp) – <i>Asking that all NCR emergency managers and CAO's participate on regional conference call</i> (EOC Cmdr on county Web) <p>Report Communication: explicitly reports a previous communication</p> <ul style="list-style-type: none"> – <i>Notifications made to EM BC443 at FS03 based on potential need for EMS on arrests</i> (EOC Cmdr on county Web) – <i>#Protesters are being told to disperse due to the civil disturbance it is causing</i> (Campus Cmdr on Chirp) <p>Other Explicit Communication: describes itself or a future communication or evaluates another communication</p> <ul style="list-style-type: none"> – <i>All persons on the [name withheld] campus are asked to evacuate campus by foot</i> (Campus Cmdr on Chirp) – <i>this is a #lie!! Campus is NOT #safe!!!</i> (student on Chirp) <p>Task Management: explicitly manages communications for EOC tasks</p> <ul style="list-style-type: none"> – <i>We have a PA on standby to represent the [LAW] at the media center</i> (Law enforcement to County on private chat) – <i>No. It is not something we normally proactively announce</i> (Law enforcement on EOC chat) <p>Source Negotiation: explicitly manages sources for communications</p> <ul style="list-style-type: none"> – <i>Users giving out misinformation are ChaosD and [] RealNews</i> (Campus Cmdr on Chirp) – <i>Several people are impersonating [LAW] on Chirp.</i> (Law enforcement on county Web) <p>Explicit Verification: communications seek to confirm or provide confirmation of other comms</p> <ul style="list-style-type: none"> – <i>has anyone been able to confirm a hostage situation on campus? chatter on Chirp about it</i> (Law on EOC chat) – <i>I have confirmed with the on scene Incident Commander and there is no radiation detected on the campus</i> (Campus Cmdr on Chirp) (<i>reports communication, too</i>)
--

Figure 3: Most Frequent Meta-Communication Functions with Examples

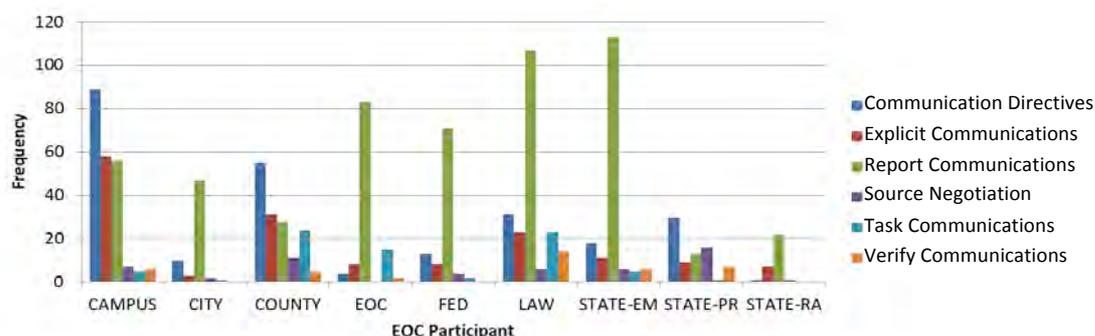


Figure 4: Frequency of Meta-communication Functions Produced by Key EOC Participant

me check with command. **Source negotiation** refers to explicit communication about which sources of information are to be trusted. (The simulation team inserted messages to emulate bad actors who might seek to spread disinformation and create confusion.) Finally, **explicit verification** refers to assertions of the veracity of a previous communication, usually using the terms "confirm" or "verify" (*Any information if this is verified?*).

Figure 4 presents counts of communication types produced by each EOC manager during the 5 day experiment. The function of reporting communications was most frequent (37%) and more than double the next most frequent type, which was communication directives (15%). These frequencies quantify a generalization that is clear to any observer of the EOC: the primary function of the EOC is communication. EOC managers require information to engage in essential decision-making and they communicate those decisions to the appropriate responders. They must coordinate with hospitals, shelters, law enforcement, and traffic control. These results also echo the findings of previous research demonstrating the significance of information-sharing in social media use during crisis events (Hughes and Palen, 2009; Hui et al., 2012; Palen and Liu, 2007; Wu et al., 2009).

The significance of information sharing in EOC communications reflects not only the imperatives of emergency management operations, but also one of the most frequently cited advantages of citizen engagement through online media. Echoing researchers' findings that social media users value information sharing and collective intelligence during emergency events, EOC managers appreciated the benefits of "citizen sensors" for situation awareness. One participant explained that it is highly effective when critical information can be acquired without committing resources that are badly needed elsewhere. This value is reflected in reports of communications such as *Chirp reporting four individuals in hoodies running past [] Library*, which was posted on the county Web portal.

Participants also quickly learned that monitoring online communications allows them to identify fears, concerns, and misunderstandings that are emerging in affected groups so that they can respond with the appropriate reports and directives that we observed. For example, the county public information officer sent the following instant message to a law enforcement manager: *Are you able to confirm/deny those black vans outside Southside and JC are yours? People are confused and fearful they are not.*

In order for online media to serve a significant situation awareness function in emergency operations, the information that is shared must be reliable. This concern raises the issue of trust, which has also been highlighted by researchers in studies of social media during crisis events. Figure 4 shows that all of the EOC participants produced communications about information sources and/or verification functions during the experiment. EOC managers and students collaborated to discriminate deceptive sources. For example, when a student chirped *Who is the best source for finding out updates for everything happening on campus??* the Campus Commander replied with the user names of the official sources. Immediately, several students and an EOC manager repeated the message using a Chirp capability that is analogous to the Twitter retweet function.

Figure 5 presents the frequencies of meta-communication message functions in each of the communication media available to managers in the EOC. Several patterns of media use are evident in the data. First, nearly all reporting of communications occurs among the EOC managers, and nearly 70% of those messages were posted to the county Web portal. Nearly 30% were messages in EOC chat, which suggests a complementary relation between the EOC Web portal and EOC chat that will be discussed below.

Another pattern of media use that emerged is the predominance of communication directives and messages annotated as *Other Explicit Communication* in the Chirp medium. Some communication directives are produced for the EOC community, such as *Please keep us posted on plans to relocate the shelter based on the plume model*, which was posted to EOC chat. But most communication directives are intended for the public and posted on Chirp: *ALERT for ALL residents: If you drove through/near campus after 6 pm and feeling ill, please*

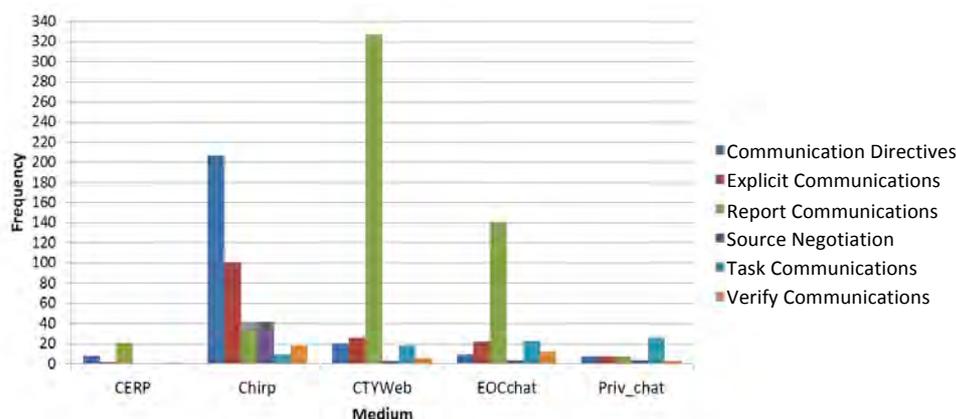


Figure 5: Frequency of EOC Participants' Meta-Communication Functions in Each Medium

call 703-817-7771, TTY 71 (County). The high frequency of messages annotated as Other Explicit Communications in the Chirp medium are primarily directives to the students that contain self-referential terms such as "advise," "remind" and "ask:" *All persons on the campus are asked to evacuate campus by foot* (Campus); *Reminder to residents to stay away from the [] campus* (County).

Other patterns evident in Figure 5 include higher proportions of source negotiation and verification functions in Chirp as EOC managers validate authoritative sources and identify deceptive messages for the students. In contrast, because task management messages are mostly about EOC manager decisions, most task management messages appear in media that are exclusive to the EOC: EOC chat, private chat, and the EOC Web portal. A strong pattern is the predominance of task management functions in the private chat messaging channel. In 70% of these messages, one of the interlocutors was a member of the law enforcement team, and many of these concerned which information would be released to the students and how those reports would be worded.

PATTERNS OF MEDIA USE

This study was conducted with the goal of obtaining a better understanding of the roles that different media might play in management of crisis events, and the results indicate several generalizations that could be investigated further. First, both students and EOC managers engaged in different patterns of use for different media. For example, both groups used CERP much less frequently than Chirp, and when they did, the meta-communication function conveyed was almost exclusively reporting communications (72% of student meta-communication on CERP was reports of communications). Therefore, this study provides evidence for the need to examine the various roles that emerge for different media and the factors that determine media use.

Second, like all communicative choices, EOC managers' use of media depended on many factors, including their roles, the communicative functions of their messages, and the affordances that each medium provides. For example, although it was used relatively infrequently, private chat provided an ideal medium for deliberations about the wording of announcements. These consultations were not the kind of information sharing that was performed on EOC chat, and they were not like the formal reports posted on the emergency management Web portal. Private chat was a confidential environment in which alternatives could be considered, and it also provided a record that could be consulted later as a reminder of exactly what wording had been approved.

Third, the data provide evidence for a significant contrast between communication media that promote more synchronous interaction such as Chirp or EOC chat and the more asynchronous environments of CERP and the county emergency management Web portal. The EOC managers' use of EOC chat and the Web portal highlights the utility they found for of both types of media. Figure 5 shows that the patterns of meta-communicative functions are nearly identical in the two media, and both were clearly used primarily as information sharing environments in which participants adopted a broadcast/announcement register. In fact, one participant often typed reports into the county emergency Web portal and then copied them into a chat message, and he commented that it would be useful if the Web portal reports were automatically routed to the chat window.

Although posting in both media may appear redundant, the affordances of each medium are very different. In the Web portal, information is accessed by locating and opening reports. In contrast, participants often kept the chat window open at the periphery of the screen where incoming messages could be easily glanced at and responded to. Messages in synchronous media are easy to produce, and they can be pushed to a window without requiring actions like selecting and opening. Therefore, the more synchronous communication media function

well for rapid interaction and alerting. However, messages can quickly move out of sight, and they are not structured in ways that facilitate retrieval at a later time. In contrast, the Web portal provides persistent, structured reports and search/filtering functions that are more appropriate for official records.

SOCIAL MEDIA FOR EMERGENCY MANAGERS

Another motivation for this study is the lack of research that examines emergency managers' use of social media both to communicate among themselves and to interact with the citizens they serve. A refined understanding of EOC communications can facilitate both the design of information and communication technology (ICT) for emergency management and the codification of operational procedures and training regimens that will be required for organizations to embrace the technology.

An example of how research that focuses on emergency managers can enrich design and adoption of ICT is the Ushahidi-based CERP portal. Although students and EOC managers used Chirp over 10 times more frequently than CERP, EOC managers clearly valued the affordances of a more structured and asynchronous medium, as evidenced by their use of the county emergency management Web portal. Another advantage of these platforms is that they are moderated, which addresses issues of reliability and trust that become significant when the medium is used for situation awareness during critical events. These issues tend to be addressed in Twitter by an "information hub" of contributors who post more frequently than others over longer periods of time (Palen and Liu 2007), which are significant predictors of non-deceptive messages (Castillo et al., 2011).

The VOST concept of a team of trusted volunteers (St. Denis et al., 2012) is an officially sanctioned information hub which allows emergency managers to leverage the expertise of physically distant contributors. But the EOC manager in the CERPS SIMEX pointed out that his county already trains citizens to serve as trusted reporters within the community, using conventional media such as telephony to provide information to the EOC. In an after-action review, he suggested that these volunteers could be trained to use CERP. This approach to the VOST concept has the advantage of leveraging local knowledge and building on an already existing organizational structure. During this discussion, SIMEX participants envisioned a goal of not only using a platform like CERP, but also integrating it with the county emergency management Web portal. The first steps toward this goal have already been taken: both the county and a state emergency management organization implemented trial Ushahidi-based sites when Hurricane Sandy struck a few weeks later.

CONCLUSIONS AND FURTHER RESEARCH

The CERPS SIMEX provided an extraordinary opportunity to document and quantify the communications of EOC managers during an emergency response. We were able to observe the communication media use of the participants and to identify the meta-communicative functions of messages in those media. The results provide evidence that different media play different roles in crisis events and that many factors influence media use in emergency management. Further research is needed to better understand these variables so that emergency managers can most effectively utilize limited communicative resources.

There are several weaknesses that limit our confidence in the specific results presented here: the data are only from a simulation, and we cannot report inter-annotator reliability for the analysis of communicative functions. Also, we were not able to analyze the entire set of communicative behaviors: while logs allowed us to examine most messages that were produced, we did not have a way to observe how messages were received. Most important, this exercise presents only a snapshot of the practices that are emerging during the ongoing, highly fluid integration of social media into emergency management. We hope that these shortcomings will be addressed in future studies.

Finally, few studies have focused on the communications of EOC managers or on the discourse functions that emerge in emergency contexts (Bharosa, Lee and Janssen, 2010; Hughes et al., 2014). We believe these kinds of analyses can provide compelling evidence for decisions that must be made in the design and adoption of ICT in crisis events, and we hope that the questions raised in this study will motivate more investigation by researchers.

ACKNOWLEDGMENTS

We are grateful for helpful and insightful comments from ISCRAM reviewers of this paper. We thank all the people involved in the CERPS SIMEX, especially the emergency operations managers who took time to participate in the experiment and share their experience and expertise. Significant credit should go to the director of MITRE's NSEL, James Dear, whose vision and leadership made the CERPS SIMEX possible.

REFERENCES

1. Bharosa, N., Lee, J.K. and Janssen, M. (2010) Challenges and obstacles in sharing and coordinating information during multi-agency disaster response: Propositions from field exercises, *Information Systems Frontiers*, 12, 49–65.
2. Castillo, C., Mendoza, M. and Poblete, B. (2011) Information credibility on Twitter, *Proceedings of WWW 2011*.
3. Condon, S. and Cech, C. (1995) Problems for Reliable Discourse Coding Systems, *Empirical Methods in Discourse Interpretation and Generation: Working Notes*. AAAI Spring Symposium Series, 27-33.
4. Condon, S. and Cech C. (2001) Talk about Talk in Face-to-Face and Computer-Mediated Decision-Making Interactions, *Cognition in Language Use: Selected Papers from the 7th Annual International Pragmatics Conference, Vol. 1*, 56-69.
5. Condon, S. and Cech, C. (2007) Ok, Next One: Discourse Markers of Common Ground. In Fetzer, A. and Fischer, K. *Lexical Markers of Common Ground*, Elsevier, 17-45.
6. Condon, S. and Miller, K. (2003) “Can you read this well?” Error Handling in a Translated Messaging Environment, *Proceedings of ISCA Workshop on Error Handling in Spoken Dialogue Systems*.
7. Dewulf, A., Gray, B., Putnam, L., Lewicki, R., Aarts, N., Bouwen, R. and van Woerkum, C. (2009) Disentangling approaches to framing in conflict and negotiation research: A meta-paradigmatic perspective, *Human relations*, 62, 155-193.
8. Emergency Disaster Management Simulation. Applied Training Solutions (ATS), LLC. (2013) Available online: <http://www.appliedtrg.com/sub/edmsim.php>. Accessed May 2013.
9. Gao, H., Barbier, G. and Goolsby, R. (2011) Harnessing the Crowdsourcing Power of Social Media for Disaster Relief, *IEEE Intelligent Systems* 26, 3, 10–14.
10. Hiltz, S.R. and Gonzalez, J.J. (2012) Assessing and Improving the Trustworthiness of Social Media for Emergency Management: A Literature Review, *Proc. Norwegian Information Security Conference*.
11. Hiltz, S.R. and Turoff, M. (1978) *The Network Nation: Human Communication via Computer*, Addison Wesley.
12. Hughes, A. L. and Palen, L. (2012) The Evolving Role of the Public Information Officer: An Examination of Social Media in Emergency Management, *Journal of Homeland Security and Emergency Management*, 9, 1, Art. 22.
13. Hughes, A. L. and Palen, L. (2009) Twitter adoption and use in mass convergence and emergency events, *International Journal of Emergency Management*, 6, 3, 248-260.
14. Hughes, A. L., Denis, L.A.S., Palen, L. and Anderson, K. M. (2014) Online Public Communications by Police & Fire Services during the 2012 Hurricane Sandy, *Proceedings of CHI 2014*.
15. Hui, C., Tyshchuk, Y., Wallace, W.A., Magdon-Ismael, M. and Goldberg, M. (2012) Information cascades in social media in response to a crisis: a preliminary model and a case study, *Proceedings of WWW '12 Companion*, 653-656.
16. Latonero, M. and Shklovski, I. (2011) Emergency Management, Twitter, and Social Media Evangelism, *International Journal of Information Systems for Crisis Response and Management*, 3, 4, 1-16.
17. National Consortium for the Study of Terrorism and Responses to Terrorism. (2012) Social Media Use During Disasters: A Review of the Knowledge Base and Gaps. Available online: http://www.start.umd.edu/start/publications/START_SocialMediaUseduringDisasters_LitReview.pdf.
18. Palen, L. and Liu, S. B. (2007) Citizen Communications in Crisis: Anticipating a Future of ICT-supported Public Participation, *Proceedings of the Conference on Human Factors in Computing*, 727–736.
19. Social Media 4 Emergency Management. <http://www.sm4em.org/>. Accessed July, 2013.
20. Sakaki, T., Okazaki, M. and Matsuo, Y. (2010) Earthquake Shakes Twitter Users: Real-Time Event Detection by Social Sensors, *Proceedings of the 19th World Wide Web Conference*, ACM Press, 851–860.
21. St. Denis, L., Hughes, A. L. and Palen, L. (2012) Trial by Fire: The Deployment of Trusted Digital Volunteers in the 2011 Shadow Lake Fire, *Proceedings of the 9th International ISCRAM Conference*.
22. StatusNet Free and Open Source Social Software. Available at <http://status.net/>. Accessed May 2013.
23. MITRE (2013) The power of a tweet: Improving emergency response with social media, *The MITRE Digest*, February 2013. Available online: http://www.mitre.org/news/digest/advanced_research/02_13/emergency_response.html.
24. Vieweg, S., Hughes, A.L., Starbird, K. and Palen, L. (2010) Microblogging during Two Natural Hazards Events: What Twitter May Contribute to Situational Awareness, *Proc. of CHI 2010*, ACM Press, 1079–1088.
25. Vieweg, S., Palen, L., Liu, S., Hughes, A. and Sutton, J. (2008) Collective intelligence in disaster: an examination of the phenomenon in the aftermath of the 2007 Virginia Tech shooting, *Proceedings of the 5th ISCRAM Conf.*, 44-54.
26. Wardell, C. and Su, Y.S. (2011) Social Media + Emergency Management Camp. Accessed July, 2013. Available online: <http://www.cna.org/sites/default/files/news/2011/Social%20Media%20Emergency%20Management%20Camp.pdf>.
27. Wu, Y., Wu, P.F. and Wang, X. (2009) Online Community Response to Major Disaster: A Study of Tianya Forum in the 2008 Sichuan Earthquake, *Proceedings of the 42nd Hawaii International Conference on System Sciences*, 1-11.
28. Yates, D. and Paquette, S. (2010) Emergency knowledge management and social media technologies: a case study of the 2010 Haitian earthquake, *Proc. 73rd ASIS&T Annual Mtg. on Navigating Streams in an Inf. Ecosystem*, 47, Art. 42.