Pass It On?: Retweeting in Mass Emergency

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ABSTRACT

We examine microblogged information generated during two different co-occurring natural hazards events in Spring 2009. Due to its rapid and widespread adoption, microblogging in emergency response is a place for serious consideration and experimentation for future application. Because microblogging is comprised of a set of practices shaped by a number of forces, it is important to measure and describe the diffuse, multi-party information exchange behaviors to anticipate how emergency governance might best play a role. Here we direct consideration toward information propagation properties in the Twitterverse, describing features of information redistribution related to the retweet (RT @) convention. Our analysis shows that during an emergency, for tweets authored by local users and tweets that contain emergency-related search terms, retweets are more likely than non-retweets to be about the event. We note that users are more likely to retweet information originally distributed through Twitter accounts run by media, especially the local media, and traditional service organizations. Comparing local users to the broader audience, we also find that tweet-based information redistribution is different for those who are local to an emergency event.

Keywords

Collective Intelligence, Crisis informatics, Fire, Flood, Information Convergence, Information Diffusion Microblogging, Social Cognition

INTRODUCTION

Microblogging applications, and specifically Twitter, are experiencing a rapid increase in their user base as well as formalization into big media, corporate communications and government communications. Because of the rapidity of microblogged communications and plurality of end-user clients and platforms, microblogging in emergency response is a place for serious consideration and experimentation for future application. However, since microblogging is comprised of a set of practices that is shaped by a number forces, it is important to measure and describe the diffuse, multi-party information exchange behaviors to anticipate how emergency governance might best play a role.

In this paper, we extend earlier analysis of microblogging behavior during mass emergency events. In related work (Starbird, Palen, Hughes and Vieweg, 2010), we describe the relationship between "generative" information behaviors in a mass emergency event and "derivative" information behaviors. That is, we examined how much new information about a specific emergency was inserted into the "Twitterverse" and by whom, and considered to what degree the information was re-used. In examining Twitter communicative activity in this way, we started particularizing ideas of "collective intelligence" (Hiltz and Turoff, 1993) and social cognition (Hutchins, 1996) to the microblogged information landscape. We continue this line of investigation to elaborate what role social media has or could have in emergency events. In particular we focus on aspects of the "derivative" information propagation function, for it was this activity that comprised, over the whole of the twitter data we collected about the event, approximately 90% of communications.

Microblogging Services and Other Social Media in Mass Emergency

Research into the use of social media during times of emergency is an area of work that is attempting to keep up with rapid state of the art change and uptake. Following the September 11, 2001 World Trade Center and Pentagon attacks, members of the public turned to the Web to search for information (Schneider and Foot, 2002), a time when blogs were not yet popularized. During this same time period, Hagar and Haythornwaite examined how farmers used computational media to find information and support one another during the lengthy 2001 UK farming crisis (2005). During the December 2004 Indian Ocean tsunami, numerous indications of socio-technical change with respect to public participation became apparent, including the use of newly available photo-repository sites (Liu et al., 2008). Several public-initiated information sources and new forms of personal ICT use sprang up in the aftermath of Hurricane Katrina, including some of the earliest housing aggregator and giving sites, people-finding activity, and map-based mashups (Palen and Liu, 2007; Torrey et al., 2007; Shklovski, Burke et al., 2008).

The tragic Virginia Tech shootings in April 2007 saw the emergence of social networking sites as destinations for collective disaster-related sensemaking, as students and others collected information on details of the shootings and reported on their own safety (Palen, Vieweg, Liu and Hughes, 2009; Vieweg, Palen, Liu, Hughes and Sutton, 2008). The resulting interactions became the basis of a highly distributed problem solving activity that "discovered," in parallel and with redundancy and apparent accuracy, the names of the 32 fatalities in advance of official releases of that information. Similar activities over a more protracted time period during the 2007 Southern California wildfires showed the centrality of ICT-enabled community information resources and other "backchannel" communications (Shklovski, Palen, Sutton, 2008; Sutton, Palen, Shklovski, 2008). The use of social networking sites in the aftermath of the shootings at Northern Illinois University in February 2008 was once again a place people turned for leveraging *widescale interaction* as they did during the Virginia Tech event, though with more apparent caution due to awareness students had about being on the public, digital stage (Palen and Vieweg, 2008). After the May 12, 2008 Sichuan earthquake in China, a popular internet forum became a location for integrating information with other people from multiple sources, organizing public action and expressing grief and anger (Qu, Wu and Wang 2009).

Work in the area of humanitarian crisis, specifically the Kenyan post-election violence in January 2008, was the basis for the creation of a "crowd sourcing" environment, *Ushahidi* (Meier and Brodock, 2008). "Community response grids" seek to similarly leverage public participation in emergency response (Wu, Qu, Preece, Fleischmann, Golbeck, Jaeger, and Shneiderman, 2008; Shneiderman and Preece, 2007). Examination of personal ICT use by Israeli and Iraqi citizens suggests that it can help people repair broken daily routines and substitute for face-to-face social interaction that is severed during ongoing, indefinite wartime disruption (Mark and Semaan, 2008). Blogs, Internet forums, and email distribution lists enabled them to communicate with people across the globe, which helped restore a sense of normalcy (Mark, Al-Ani and Semaan, 2009).

Information Propagation within the Twitterverse

In the work presented here, the guiding idea is that members of the public can produce and redistribute information that helps resolve any number of issues that arise in times of emergencies or prolonged disruption. We aim to focus in on the particular behavioral aspect of information propagation—the "passing on" of information from one person to the next—in the Twitterverse.

Twitter

Twitter is a popular micro-blogging social media platform that enables communication between networked users. Users (Twitterers) can broadcast an unlimited amount of messages (tweets) to a group of other Twitterers who have opted to subscribe to these broadcasts (followers). Twitterers also receive broadcasts from other users to whose account streams they subscribe or are "following." Individual tweets are limited to 140 characters. The Twitter platform supports both broadcasting and receiving tweets through an online web portal and via the text-messaging feature on most mobile phones. Additionally, a variety of third-party applications enhance Twitter service on the web and mobile platforms (eg., TweetDeck, twitterfeed, TwitterBerry, echofon).

Each Twitter account has a profile that contains a chosen name, location, bio and a list for both the followers and the accounts he or she is following. Previous research indicates that there are a variety of different account types, including individuals, local and national mainstream media, alternative media, service providers, representatives of established businesses, small business promoters, among others (Starbird et al., 2010).

Tweet Conventions

A number of linguistic conventions have emerged since Twitter's first release in 2006. Though emerging norms have been user-driven (boyd, et al., 2010), Twitter continues to add functionality to support some conventions within the system, including the user designation, the hashtag, and the retweet[1]. The hashtag convention (`#[hashtag term]`) is used inline to call out user-chosen keywords. Hashtags tag or markup a tweet to help others understand the content context, as well as support keyword term-searching. They are often appended at the end of a tweet. More evolved use of hashtags incorporate the hashtag symbol into fluid text to maximize

[1] As of November 2009, this feature had been added in Beta version to some users' Twitter portals. At this time, it adds a new symbol to designate RTs and provides information as to how many times that tweet has been retweeted within the set.

limited character string use. Twitterers incorporate the `@` symbol and the `@[username]` convention within a tweet to designate another Twitter user. This can be used to show that a tweet is directed to or referring to another Twitter user. The retweet (`RT @[username]`) builds on top of this convention. It allows Twitterers to attribute authorship to the original tweet authors while re-broadcasting or forwarding the tweet, propagating a tweet from the initial set of followers (1st degree connections) to the subscriber's followers (2nd degree connections). In Starbird et al. (2010), we reported on the presence of the "`follow @[username]`" convention, whereby Twitter users recommend another Twitterer for following.

Retweeting Behavior

In our earlier research on *derivative* information propagation behaviors, we found that Twitterers use the retweet convention as an informal recommendation system, to pass on information they feel is important for others to know (Starbird et al., 2010; Vieweg, Hughes, Starbird & Palen, 2010). In that work, we reported that over 10% of all emergency-related tweets sent by people who were geographically local to the event were retweets. We also found that for the majority of retweets by individuals, the original authors of those tweets were more likely to be local to the event.[2]

Here we elaborate on these findings to account for retweeting behavior, considering what kind of information is propagated within the world of Twitter at large (the "Twitterverse") as well as localized to a geographic event.

DESCRIPTION OF EVENTS

Spring 2009 Red River Flooding (USA)

The Red River flows along the border of North Dakota and Minnesota, in the USA, originating just south of Fargo, running to the north across the US-Canadian border into Winnipeg, Canada. The shallow topography and northerly flow make it susceptible to seasonal springtime flooding because of ongoing upstream thaws and downstream freezes (Schwert, 2003). In 2009, residents of the Red River Valley were first warned of potential flooding in late February (USA Today, 2009). The Red River crested in Fargo on March 28 at a new all-time record height, though major flooding was averted through levee engineering and fortuitous weather. However, a second flood crest was predicted for mid to late April for Fargo (NOAA, April 3, 2009) as downstream townships monitored conditions and were under threat and flood conditions for many weeks.

Spring 2009 Oklahoma Fires (USA)

A second, concurrent event occurred on April 9 when high winds and dry conditions fueled several grassfires throughout central and southern Oklahoma plains as well as parts of northern Texas. In Oklahoma, many neighborhoods were evacuated as firefighters tried to control spread through the heavy, dry brush and spring grass. The immediate fire threat continued through mid morning April 10. In total, over 60 injuries were reported and 31 counties were declared a state of emergency. Close to 270 buildings were destroyed, 228 of which were homes, and over 100,000 acres burned (McNutt, 2009; OK.gov, 2009; KOCO, 2009).

METHOD

Data Collection

Twitter maintains a suite of search tools, the Twitter Search API, which allows programmers to write software that accesses information about tweets in the public timeline. The public timeline carries all tweets within a specific time window that were authored by Twitterers whose accounts are designated as public (the default). Searches provide individual tweet information including text and timestamp as well as links to the tweet author's profile information.

Using the Twitter Search API, we collected data for each event in two necessary phases. The first phase used case-insensitive search terms designed to collect the broadest sample with the least amount of noise: `red river` and `redriver` for the Red River Floods and `oklahoma, okfire, grass fire` and `grassfire` for

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[2] Determinations of locality were made by reading users' entire tweet streams and comparing that to any profile reporting of their location (which isn't always reflective of where they actually are)—this was the only way to do this with a high degree of accuracy.

the Oklahoma grassfires. These data were collected into keyword-marked *Twitterverse Proxy Set* for both events, which because of its range, we use as a sample or proxy of the whole of the activity in the Twitterverse on these emergency events in this analysis (which will be made clearer later in the paper).

In the second phase, we identified from the *Twitterverse Proxy* Sets users who were individual contributors local to the event (because they lived there, or because they visited the region during the emergency). The *Local-Individual Sets* include those who had tweeted more than 3 keyword-containing tweets during the event. This was a sampling threshold decision to capture active twitters in the event and reduce noise, and to put the set at a level where each tweet could still be analyzed qualitatively one by one (though the task remained ambitious). We then collected the full tweet streams for these found Twitterers, regardless of tweet content, during the time frame, and analyzed (through qualitative coding) all of those tweets as well for surrounding context and to capture event-related tweets that did not contain the search terms.

The data collection window for each event was designed to capture the entire warning and impact phases for all locations affected. The Red River data were collected across 51-days, spanning from the warnings in early March to the final crest in Winnipeg in late April. The Oklahoma grassfire data cover a much shorter window, from April 8, one day before the event, through April 13, after the threat had ceased. Table 1 shows the number of tweets in each data set as well as the number of Twitterers who contributed those tweets.

Every tweet in each set was qualitatively coded as on- or off-topic to the emergency event. The percentage of on-topic tweets (see Table 2) varies between events and across the different data sets (Proxy vs Local-Individuals). While the keyword searches for the Red River set produced a relatively low noise sample, only one-third of the OK Fires *Twitterverse Proxy Set* is on-topic. Also, because the *Local-Individual Sets* represent full user streams including tweets that do not contain search terms, they are far less likely to be on-topic overall.

Data Set	Total # Twitterers	Total # Tweets
Red River Broad Tweet Set (a set defined by keyword search that acts as a proxy for the Twitterverse on the topic) **"RR Twitterverse Proxy"**	4983	13,153
Red River Tweet Streams from Individuals who Live Locally **"RR Local-Individuals"**	49	19,162
Oklahoma Fires Broad Tweet Set (a set defined by keyword search that acts as a proxy for the Twitterverse on the topic) **"OK Twitterverse Proxy"**	3852	6674
Oklahoma Fires Tweet Streams from Individuals who Live Locally **"OK Local-Individuals"**	46	2779

Table 1. Data Set Descriptions

Algorithm for Tracking Retweets

Though the convention for retweets is converging around the designation of "RT @", there is still considerable variation in retweeting language/symbols and in the presentation and/or alteration of original tweet text (boyd, et al., 2010). This makes the propagation of retweets through a large data set difficult to track. Some Twitterers use alternative conventions, including using "via username" and/or place the "RT @" at the end of the retweet. Occasionally, words are shortened or text is altered to fit the retweet and the author attribution into the 140-character limit. When they fit, hashtags and comments are often added. Some authors neglect to include the author attribution, and simply copy the text or a version of the text into their new tweet. For these reasons, a simple comparison between two tweets will not always determine whether one is a retweet of the other.

To estimate the popularity of individual tweets and visualize their propagation through the different data sets in this study, we used a three-part algorithm to determine if one tweet was a retweet of another. We compared all tweets that contained "RT @" against all other tweets in the set. Initially, the algorithm did a simple string compare (excluding the RT @username) to determine if the tweets were an exact match. If an exact match was not found, tweets with more than six words were then compared for a similarity of word inclusion. If 90% of words present in the shorter tweet were found in the longer tweet and all numbers and URLS were an exact match, then the tweets were marked as related. Finally, if the first six words from both tweets were identical and all numbers and URLS matched, then a match was determined. If none of these three conditions were met, the tweets were determined to be unrelated. Manually checking all matches indicated that no false matches were made in any of these sets, though several potential matches were not recognized. Therefore, the current algorithm under-reports matches. This also means that the numbers used to determine popularity of individual tweets occasionally underestimate the actual number of times that a tweet was retweeted in the data sets.

RESULTS

Retweets comprised 6.3% of our *Twitterverse Proxy* sets and 8.9% of our local user's streams. Our findings indicate that these **retweets are more likely than un-retweeted tweets to be about the emergency event.** Across all data sets, the percentage of retweets that are on-topic is significantly higher than the percentage of non-retweets that are on-topic. This effect is particularly strong for the OK Fires Twitterverse Proxy set, due in part to the large amount of noise in the overall sample. These results suggest that identifying retweets within both broader and local-individual samples can lead to information that has a higher probability of being relevant to the emergency event. Using retweets as a "relevance filter" could be especially valuable in high-noise samples.

Data Set	*TOTAL % On-topic Tweets*	Non-retweets: % On-topic	Retweets: % On-topic	Chi-Square, p value
RR Twitterverse Proxy	*92.0*	91.8	95.1	13.4, p < 0.0005
RR Local Individuals	*13.6*	13.1	18.4	39.7, p < 0.0005
OKFires Twitterverse Proxy	*33.0*	31.3	68.5	177.6, p < 0.00001
OK Fires Local Individuals	*27.6*	26.4	42.5	24.0, p < 0.0005

Table 2. Percentage On-Topic for Non-Retweets vs Retweets

Who is Retweeted?

Another important aspect of retweets is their authorship. Our research suggests that retweets act as an informal recommendation system for both the information and the original author (Starbird et al. 2010). Analyzing the number of times that a given Twitterer is retweeted within a data set provides one measure of popularity or source value for that account. This measure differs from the overall popularity or broadcast extent of an account, which can be measured by capturing the number of "followers," in that it suggests value both specific to the emergency event and beyond the confines of the Twitterer's first-degree social network.

To determine which Twitterers were mostly highly valued during these events we examined both *the number of retweets attributed to each author* as well as the *number of different Twitterers who retweeted information attributed to that author*. This second measure allows us to see which information reaches the most people and eliminates Twitterers who were retweeted a high volume of times by a limited number of individuals; for several accounts that were often retweeted, a single Twitterer did almost all of the retweeting.

In line with our earlier findings on just the Red River event (Starbird, et al., 2010), the **Twitterers whose tweets were retweeted the most almost always belonged to mainstream media (especially local media), service organizations, or accounts whose explicit purpose was to cover the emergency event**. We can now verify that this trend at least holds for the Red River and Oklahoma grass fires events, both for local individuals as well as the rest of the Twitterverse.

In fact, only three of the highly-retweeted Twitterers were non-affiliated individuals in the Red River and Oklahoma data sets. Of these, one in each of the events—`@stevedrees` (in Red River) and `@mkokc` (in OK Fires)—were local. `@caseywright`, a non-local, was the mostly highly retweeted individual in the Red River event because of the widespread propagation of a single tweet, discussed at further length below.

Red River Floods

The Flood Specific Service (FSS) accounts were the most highly retweeted accounts in the Red River *Twitterverse Proxy Set*. These accounts, discussed more deeply in Starbird et al. (2010), were each created by a different local individual and distributed exclusively flood-related information during these events. Most of these accounts broadcasted tweets that were automatically populated by computer scripts and relayed flood height information from a specific location at regular intervals using data posted online by the US Geological Survey.

Tweets from the `inforum` twitter account were retweeted by the highest number of different local individuals (See Table 3). `Inforum` is a Ning-based social networking site attending to issues local to the Fargo-Moorhead area. Fourteen of the 49 local individuals retweeted at least one `inforum` tweet. Both the high volume of retweets and the high number of Twitterers who retweeted information originating in this account indicate that `inforum` was a highly valued local resource by those who used Twitter during the Red River flooding event.

Twitterer	# Times Retweeted	# of Twitterers who Retweeted Column A's tweets	Account Description
Red River Twitterverse Proxy			
redriveratfargo	116	53	FSS account – auto
caseywright	29	28	Non-local author of 1 popular retweet - "Amazing pics…"
RedRiverFlood	29	27	FSS account – manual
MPR	29	26	MPR – Minnesota Public Radio
RedCross	26	24	Red Cross
Inforum	20	20	local social media site
fargofloodstage	30	16	FSS account – auto
Red River Local Individuals			
Inforum	34	14	local Ning-based social networking site
redriveratfargo	27	11	FSS account – auto
RedRiverFlood	7	6	FSS account – manual
Stevedrees	23	6	local twitterer
FargoMoorhead	7	5	Fargo-Moorhead Convention and Visitors bureau
ViewsNews	7	5	Local Alternative Media

Table 3. Statistics for most retweeted Twitter accounts during the Red River event

Oklahoma Fires

In keeping with the overall finding, during the Oklahoma grass fires event, the most highly retweeted Twitterer was a local news account, `NewsOK`. Other news media accounts and official emergency organizations like the Red Cross and Oklahoma Emergency Management were also highly and widely retweeted across a broad audience and among local individuals.

Twitterer	# Times Retweeted	# of Twitterers who Retweeted Column A's tweets	Account Description
Oklahoma Fires Twitterverse Proxy			
NewsOK	18	15	local news - Oklahoma City
NEWS9	13	11	local news - CBS – Oklahoma City
Okem	11	11	Oklahoma Emergency Management
RedCross	10	9	Red Cross
mkokc	9	8	local twitterer
redcrossokc	12	7	Red Cross
Okie_Campaigns	7	7	local Twitterer from Norman, OK
Oklahoma Fires Local Individuals			
NewsOK	11	7	local news - Oklahoma City
mkokc	9	5	local twitterer
okem	6	5	Oklahoma Emergency Management
NEWS9	5	4	local news - CBS - Oklahoma City
OkCountySheriff	3	3	OK County Sheriff's Office
cityofokc	5	3	City of Oklahoma City
redcrossokc	6	3	Red Cross Oklahoma City

Table 4. Statistics for most retweeted Twitter accounts during the Oklahoma Fires Event

What Information is Being Retweeted?

Broad Appeal

As determined by our retweet-match algorithm, the most popular retweets across the entire Twitterverse for both the Red River and Oklahoma Fires events typically contained general information with broad appeal for a large, distributed audience. These tweets that had broad appeal were most often propagated by Twitterers who were not directly affected by the event. Several contained prayer requests and notably, few of these came from locals.

The most popular retweeted tweet was originally authored by non-local @caseywright:

```
RT @caseywright: Amazing pics of Red River flood in North Dakota: http://bit.ly/187pF
```

It was retweeted at least 29 times. 23 of these retweets were distributed by Twitterers who only broadcasted a single tweet containing a Red River search term, which was likely their only contribution to the Twitter conversation surrounding the event. In contrast, this tweet has a much lower profile among locals. It was not important enough to rank among their top retweets.

RT @caseywright: Amazing pics of Red River flood in North Dakota: http://bit.ly/187pF
RT @NASA: See the Red River floods in snowy North Dakota as captured by a NASA Earth-observing satellite last weekend. http://tr.im/i34b
RT @RedCross: Real time flood resources and updates http://tinyurl.com/dlscn5 #fargoflood #ndfloods #redriver #floods09
RT @SocialMedia411: Lets all have a good thought for those in the Red River Valley as flooding looms. MUST SEE PHOTOS http://bit.ly/2lIm5L

Table 4. Top 4 most popular retweets in the Red River Twitterverse

RT @RedCross: We're responding to grass fires in Oklahoma. Follow @RedCrossOKC for local updates. #okfire
RT @ScottWilliams: Tweeps please pray for the families and firefighters battling these crazy fires in Oklahoma. http://bit.ly/MJxv #okfires
RT @NewsOK: Authorites say 50 homes have burned to ground in Midwest City #OKFires #OKFire
RT @jasonmitchener: Please #pray4 those affected by the fires in Oklahoma and Texas.

Table 5. Top 4 most popular emergency-related retweets in the Oklahoma Fires Twitterverse

Local Utility

The most popular retweets among locals were tweets containing much more locally relevant information, more so than the popular retweets in the broad audience discussion. Among Red River locals, the two most popular retweets relayed information from `@inforum`, a valued local resource discussed above. Other popular retweets relayed information about sandbagging coordination efforts, road closures, and river levels. For example:

```
RT @inforum set up a network today, so people can communicate w/each other.
http://flood.inforum.com/ It uses ning, need to register.

RT @LYLEHALVORSON: Hwy 1806 closed in prep for explosions to clear ice on Missouri Rvr.
Adv: Stay away from windows. #ndfloods #floods09

RT @cbensen: WOW - Fargo needs 900 k more sandbags, students are excused tomorrow to help
&amp; its raining tonite - theyre getting nervous
```

In the Oklahoma Fires event, among locals, the most retweeted tweets contained highly specific, emergency-related information relevant to other local users. Shelter information (human and pet), fire lines, and first-person observations of the emergency were all popular retweets. This suggests that local Twitterers are not attempting to address a broad audience. Instead, they use retweets to pass on information they feel will be valuable to other locals, as illustrated here:

```
RT @cityofokc: OKC Animal Control is on the scene at 149th and Hiwasee with a response
trailer. #okfires

RT @joneyee: #okfire New Community Church at I40 and South Anderson Rd has opened for
Evacuees

RT @rustysurette: BIG fire south of downtown OKC.  Thick smoke covering the metro.  Its a
grass fire in Newcastle.
```

The Distribution of a Notable Tweet

The most retweeted tweet in any of our data sets was `@caseywright`'s tweet advising followers to check out a link to "Amazing pics" of the Red River flooding situation. This tweet contained a shortened link[3] to a picture gallery called "The Big Picture" posted online at boston.com. Below are the original tweet and a typical retweet.

`@caseywright (2009-03-27 15:05:11): Amazing pics of Red River flood in North Dakota: http://bit.ly/187pF`

`@MrsRobinson17 (2009-03-27 19:14:46): RT @caseywright Amazing pics of Red River flood in North Dakota: http://bit.ly/187pF`

The *Red River Twitterverse Proxy* contains at least 42 retweets related to `@caseywright`'s original. Figure 1 shows the propagation of this retweet through the data set. Tweets that are probable retweets are in blue, while algorithmically-determined retweets (tweets-as-content matches) are dark spheres. Vertical lines represent days, with time moving left to right. The majority of these retweets occurred on same day of the original tweet, March 27, less than 24 hours before the river crested. The final retweet occurred two days later on March 29.

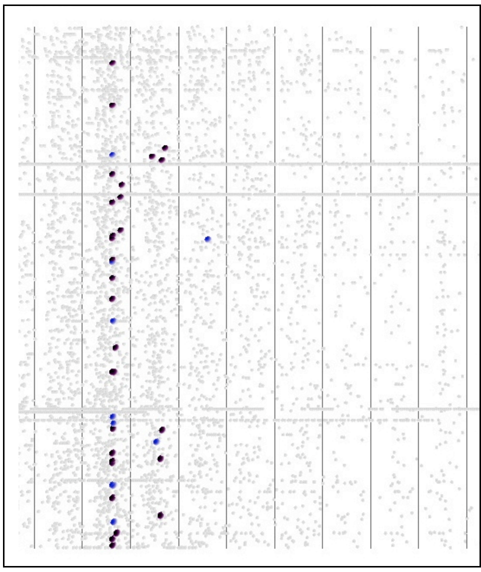

Figure 1. Retweet propagation for @caseywright's "Amazing pics" tweet Mar 26 – Apr 3

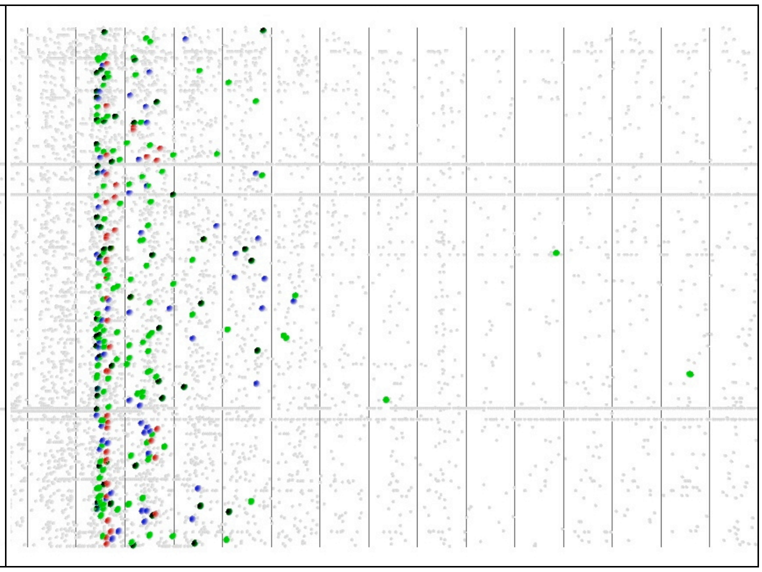

Figure 2. Tweet and retweet propagation for all "Amazing pics" and "Big Picture" tweets Mar 26 – Apr 9

Due to the high volume and varied nature of derivative or re-use behavior within the data set, the life-cycle of a popular tweet like @caseywright's can be much more complex than a simple retweet propagation. Within the *Red River Twitterverse Proxy* we located several other tweet-retweet patterns that contained similar language and/or linked to the same boston.com "Big Picture" webpage. Many of these preceded `@caseywright`'s (supposedly) original tweet, and we can only speculate about the origins of each. For instance, it is possible that `@caseywright` received a similar tweet with a link to that webpage and crafted a new tweet with the link.

In all, we found 290 tweets in the Red River Broader Twitterverse data that reference the boston.com photo article. Figure 2 shows how three different versions of tweets containing this information propagated over time within the set. Red spheres represent "Amazing pics" tweets, blue spheres contain reference to "The Big Picture" and green spheres contain any of the three most-used shortened URLs. Tweets that contain combinations of these terms appear in darker shades. Examples of variations on this tweet include the following:

`johnnyA (2009-03-27 10:04:49) : Red River flooding photos http://tinyurl.com/cqpbqa`

`jmdillon (2009-03-27 11:14:48) : Amazing photos from The Big Picture - Red River Flooding - http://tinyurl.com/cqpbqa`

`@mjbutleruk (2009-03-29 14:50:01) : Amazing pics of Red River flood http://tinyurl.com/cqpbqa`

This account demonstrates both the complexity of tracing tweet origins and the intense re-use activity occurring in the Twitterverse. It also shows how a single idea or link can be quickly and massively distributed and re-

[3] There are several services, including TinyURL and bit.ly, that generate shortened URLs for existing online links. These TinyURL service creates a single new link at the first request and subsequently distributes that link to anyone who requests a shortened URL for that same online address. The bit.ly service assigns a unique URL for every request.

distributed to a wider Twitter audience. These 290 tweets constitute 2.2% of the Twitterverse's keyword-marked conversation around the Red River events. It is notable that one idea accounts for such a large percentage of the larger discourse and yet had relatively little uptake among local Twitterers.

CONCLUSION

This paper examines the role retweets play as a mechanism for the propagation of emergency-related information within the Twitterverse during emergency events. Our data show that during an emergency, keyword-containing retweets and retweets from geographically local people are more likely than other tweets to pertain to the event. At a broad level, this suggests that focusing on retweets may help to reduce noise during data collection and real-time analysis of tweets during emergencies. Perhaps more significantly, this also indicates that locals are more likely to use the retweet convention to pass on emergency-related information than other types of information during the event. This trend supports the idea of retweets performing a recommendation role within the Twitterverse, as locals actively choose to spread this type of information over others. These are observations that emergency management information systems (EMIS) could consider for incorporation and processing of social media content.

Our research also indicates that local media and established emergency management agencies continue to be valued sources for information. This is not to say that new sources are not valued as well—they are (as measured by retweeting). However, though the popular rhetoric around Twitter continues to emphasize its equal-opportunity, participatory nature, the role for formal emergency management organizations on the social media stage remains welcomed. Alignment of informal and formal sources of information is the way forward (Palen, Anderson, Mark, Martin, Sicker, Palmer, Grunwald, 2010).

Analysis of this retweet propagation across different types of Twitterers and their proximate/non-proximate locations also helps explain how information is differently valued. Generally, the broader Twitter audience demonstrates interest in the high-level or journalistic account of an emergency event. Because locally-specific information has little meaning to them, they use the retweet to forward headlines and links that capture the "abstract" of the event, or pass along photos that invite fleeting, sympathetic or perhaps even voyeuristic attention. Tweet patterns of individuals who are local to the emergency show the retweet being used to distribute a different type of information, one that is more specific and locally relevant. It is not surprising to see locals valuing and therefore propagating more locally-relevant and -helpful information, but it is meaningful to begin to think of Twitter and other social media as serving multiple different functions among different user group spheres during different events. Generalizations about the triviality of Twitter communications at the broad level therefore will not necessarily hold for tweets sent, received, and retweeted during an emergency event. As Twitter behavior continues to evolve, we can expect to see the adaptation of a tweet's 140 characters to diverge, depending on the status of the Twitterer as a local or virtual bystander.

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