Microblogging after a Major Disaster in China: A Case Study of the 2010 Yushu Earthquake

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ABSTRACT
In this work, we conducted a case study of a popular Chinese microblogging site, Sina-Weibo, to investigate how Chinese netizens used microblogging in response to a major disaster: the 2010 Yushu Earthquake. We combined multiple analysis methods in this case study, including content analysis of microblog messages, trend analysis of different topics, and an analysis of the information spreading process. This study helped us understand the roles played by microblogging systems in response to major disasters and enabled us to gain insight into how to harness the power of microblogging to facilitate disaster response. In addition, this work supplements existing works with an exploration of a non-Western socio-cultural system: how Chinese Internet users used microblogging in disaster response.

Author Keywords
Microblogging, Disaster Response, Yushu Earthquake

ACM Classification Keywords
H.5.3 Group and Organization Interface – Collaborative computing, Computer-supported cooperative work, Web-based interaction; K.4.2 Social Issues; K.4.3 Organizational Impacts – Computer-supported collaborative work

General Terms
Human Factors

INTRODUCTION
More and more evidence shows that citizen-driven emergency response is a critical part of an effective response to major disasters. Information and Communication Technologies (ICTs) may greatly empower such responses. Among emerging ICTs, microblogging systems have shown potential in facilitating emergency response as they provide an information platform with easy accessibility, where short messages can be swiftly composed and shared among large numbers of people. For example, Twitter was actively used to provide real time situation updates during the 2007 California Wild Fires [5,23], the 2009 Red River Floods [21,25], and the 2009 Oklahoma Grassfires [25].

To better understand the role played by microblogging systems during major disasters, and how disaster-related information is spread through such social media, we conducted a case study to investigate how Sina-Weibo, a popular Chinese microblogging system, was used immediately after a major disaster – the 2010 Yushu Earthquake. Combining content analysis of microblog messages, trend analysis of different topics, and an analysis of the information spreading process, we gained insight into the information dynamics in the microblogging system during and after the major disaster, including how different types of information developed over time and how information was spread in the microblogging network. In addition, this work supplements the currently Western culture oriented literature with an exploration on how Chinese netizens use microblogging in emergency response.

The paper is organized as follows: We first introduce related works, and then proceed to describe our data collection processes and methods, followed by descriptions of our data analysis process and results. We conclude our paper by summarizing findings and discussing several key issues.

RELATED WORK

ICTs & Citizen-Driven Emergency Response
There is a growing body of literature about how Information and Communication Technologies (ICTs) have been adopted in citizen-driven emergency response. Jaeger et al. [10] studied the role of public libraries in the relief of the 2004 and 2005 Gulf Coast hurricanes. Residents in the affected areas used public libraries to check for situation updates, look for missing family members, and

communicate with friends and relatives. Hager [7] investigated how a local farmer community used a grass roots computer network at the height of the foot and mouth disease crisis in the UK. The network provided a virtual community space for local farmers to exchange information, talk to each other, and provide emotional support. Torrey et al. [24] studied how an online forum was used to facilitate and coordinate the distribution of donated goods. Qu et al. [17] analyzed people's response to the 2008 Sichuan earthquake on a Chinese online forum. They identified the forum's main functions: to provide a communication and information sharing platform for people to seek, share, and synthesize information, to enable the expression of emotions and opinions, and to support relief coordination. Shneiderman and Preece proposed the Emergency Response Grid – an information infrastructure that supports citizen-driven emergency response [19]. These studies pointed out the importance of citizen-driven emergency response when facing major disasters and the potential of adopting ICT in this area.

Recently, microblogging systems – a new type of social media with unique features such as the 140 character limit, easy accessibility, and light-weight operations, have drawn increasing attention from research communities. Studies have examined the use of microblogging systems in the response to mass emergency events and have proposed methods to harness the power of such social media in disaster response. Most noticeably, a group of researchers from University of Colorado examined various aspects of the use of Twitter in the 2009 Oklahoma Grassfires and the 2009 Red River Floods. Vieweg et al. analyzed tweets posted by people who were "on the ground" and examined the potential of using Twitter as a source for situation update [25]. Starbird et al. investigated the "social life" of microblogged information, and identified four types of information evolution: generative, derivative, synthetic, and innovative activities [21]. Starbird and Palen [20] analyzed what types of information are more likely to be retweeted after disaster events.

However, there are still many open questions regarding the potential use of microblogging systems in emergency response. For instance, besides situation update, what other activities do people use Twitter for? How does people's attention shift among different types of information during the course of a developing disaster event? How does disaster-related information spread in the tweeting and retweeting process? Furthermore, existing literature is largely based on data collected from the Twitter system, which rooted in North American culture. There is gap in the existing literature on diverse socio-cultural systems.

General Studies of Microblogging Systems
There is a continually growing body of literature on microblogging. Even though these studies do not specifically explore the emergency response context, they still provide a basic understanding of community structure

and information diffusion in microblogging systems, which is essential for exploring the use of microblogging systems in emergency response. For instance, existing studies showed that people use microblogging systems for both social interactions and informational purposes [8,11,16]. At the same time, social network and trend analysis revealed the community structures and the evolution of topics [2,11,12]. Several models attempted to characterize the information diffusion process [1,6,28]. In particular, researchers are interested in how and why people retweet – how information is spread in microblogging systems. Factors related to tweet content, user similarity, and user personality were explored [3,4,13,18,22,27]. However, previous works have not fully explained the information diffusion patterns observed in empirical studies, such as the short lengths of email forwarding chains [26] and product recommendation chains [14], and the diffusion tree of chain-letters with long paths but few branches reconstructed by Liben-Nowell and Kleinberg [15].

Our work focused on empirical descriptions of the spreading pattern of disaster-related information in microblogging systems. By combining content analysis, trend analysis, and information diffusion analysis, our work revealed how different types of information evolve and spread in microblogging systems.

DATA AND METHODS

The 2010 Yushu Earthquake in China
The 2010 Yushu Earthquake occurred in Yushu, Qinghai province, China, at 7:49am, April 14, 2010 local time (Figure 1). The magnitude was 7.1M according to the China Earthquake Administration (CEA) [1]. There were 2,698 people confirmed dead, 270 missing, and thousands more injured or homeless according to the Xinhua News Agency [2]. The earthquake quickly gained national and worldwide attention after it happened. April 21 was declared a national day of mourning in China. A national evening gala hosted on China Central Television on the evening of April 20 raised 2.2 billion Yuan (322 million US$), which exceeded the amount raised during a similar event in the 2008 Sichuan Earthquake [3].

In addition to the non-stop news coverage in traditional media outlets, the event also swept social media sites in China. Netizens in various online communities responded to the disaster by seeking and sharing information, expressing their feelings and opinions, and organizing donation and relief activities. Among them, Sina-Weibo, a

[1] http://www.cea.gov.cn/manage/html/8a8587881632fa5c01 16674a018300cf/_zqzqdzxx/_content/10_04/14/d6b0d67d-59f6-4ae2-967a-389c75f05fdf.html

[2] http://news.xinhuanet.com/english2010/china/2010-05/31/c_13325439.htm

[3] http://www.telegraph.co.uk/news/worldnews/asia/china/76 14013/China-mourns-victims-of-Yushu-earthquake.html

newly emerged Twitter-like microblogging system in China, became one of the most active social spaces for these activities.

Figure 1. Yushu Earthquake Location Map[4]

Sina Weibo

Sina-Weibo is a Twitter-like microblogging system in China provided by Sina, one of the largest Chinese Internet content providers. It was launched in August, 2009 and quickly become the most popular microblogging service in China. By March 2010, it had reached 5 million users[5]. The current number of users has not been published yet but we believe it should be significantly higher, given the rapid adoption of this system by Chinese Internet users.

Sina-Weibo's interface is similar to Twitter. It has a 140 character limit. A user's messages are broadcast to his/her followers, who can in turn forward the messages to their followers. However, rooted in China, Sina-Weibo is different from Twitter from several perspectives. First, it allows blog-like comments. Unlike "replies" in Twitter, Sina-Weibo's has a "Pinglun" (comment) feature, where the comments on a message do not appear independently in the feed of the user who made the comment, but rather are listed under the original message. Second, "VIP" accounts (originally named "MingRen") play a very important role in Sina-Weibo. Different from "verified accounts" in Twitter, VIP accounts in Sina-Weibo are only given to well-known celebrities and brands. These VIPs have gained thousands to millions of followers. For instance, the most popular VIP user, Yao Chen, a young actress, has 2,329,968 followers. All VIPs are listed in the "Hall of Fame" and are often recommended by the system to new users.

In this paper, we will use the word "post" for the publishing of a microblog message, and the word "re-post" for the

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[4] http://news.xinhuanet.com/english2010/database/2010-04/14/c_13250759.htm

[5] http://english.sina.com/technology/p/2010/0617/325089.html

forwarding of an existing microblog message, which are analogous to the terms "tweet" and "retweet" in the Twitter system. We use the word "message" as a general term covering both post messages and re-post messages.

Data Collection

We collected 94,101 microblog posts and 41,817 re-posts related to the 2010 Yushu Earthquake on Sina-Weibo during a 48-day period immediately after the earthquake. The 48-day window started from 7:49 am, April 14, 2010 (local time) when the earthquake struck and ended at 23:59 pm, May 31, 2010.

Our data was gathered mainly by submitting two queries: "玉树+地震" ("Yushu AND Earthquake") and "青海+地震" ("Qinghai AND Earthquake") to the Sina-Weibo search interface and extracting posts and reposts from the search result pages. Sina-Weibo only returns up to 15,000 messages per day per query. Fortunately, only the query "Qinghai AND Earthquake" reached the maximum once, when retrieving messages sent on April 21- the national mourning day. We lost about 800 messages for that day. In total, we retrieved 93,643 Yushu Earthquake related microblog messages from these two queries. Note that this is a subset of all the Yushu earthquake related messages because we missed other relevant messages that do not contain those queried keywords.

For each of the retrieved microblog messages, we extracted basic information including the author's name, message content, publication date, and the total number of re-posts of this message. We also scanned the profiles of the authors of these messages and gathered related information, including number of messages the author posted or re-posted, the number of followers, the number of followees, and whether the author is a certified VIP member.

Another data set that we collected is all the Yushu Earthquake related re-posts from the VIPs. We downloaded the VIP list from the "Hall of Fame". We crawled each VIP user's profile page and identified any re-posts of our collected earthquake related messages.

Data Analysis

We aim to explore the following questions in this study:

Q1: What kinds of messages do people post after a major disaster?

Q2: Are there different posting and re-posting behaviors in respect to different types of information and different phases during the disaster response period?

Q3: How does disaster-related information spread in a microblogging system?

To address Question 1, we developed a classification scheme and did content analysis of the microblog messages. To address Question 2, we examined trends of different types of messages. We tended to answer Question 3 by

examining the re-posting patterns. An original post is visible to the author's followers. It is exposed to more people when those people re-post (forward) the original message. Therefore, the spread of information in the microblogging system can be caught by recording the re-posting paths. We examined the re-posting under different post categories and inspected different factors that may affect the number of re-posts of an original message.

Content Analysis
Our first task was to examine what types of messages people post in the micro-blogging system in response to the disaster. To conduct the analysis, we randomly sampled 5% percent of the collected microblog messages (4618 messages). We then developed a microblog messages classification scheme and categorized the sample set. The content analysis revealed the basic roles of the microblogging system in disaster response.

Our development of the classification scheme for earthquake related microblog messages followed a mixed process: we identified topics from our sampled messages in a bottom-up manner and also adopted categorization ideas from existing literature in a top-down manner [17,25].

We iteratively coded the sampled messages: Two researchers collaboratively drafted an initial classification and coding scheme mainly based on Qu et al. [17] and Vieweg et al.'s [25] work. Then they skimmed through the sampled microblog messages and revised their initial coding scheme independently. They discussed their classification coding schemes and reached consensus on an integrated classification and coding scheme. They then independently coded 200 random posts from the 4618 sampled posts. The overall Cohen's Kappa is acceptable (74%). The two researchers then discussed the inconsistencies in their coding and further clarified the coding criteria. They then applied the classification and coding scheme on the rest of the 4418 sampled messages.

Trend Analysis
In a follow-up trend analysis, we examined the distribution of different message categories over time. The trend analysis revealed the attention and activity shift during different phases of emergency response.

Information Spreading Analysis
When a person posts a microblog message, the message is broadcast to her/his followers. That piece of information is further disseminated when those followers re-post the message to their followers. To understand this spreading process, we analyzed the re-posting paths of the disaster-related messages.

We randomly sampled and classified 3973 VIP-posted messages with at least one re-post, and 3686 non-VIP-posted messages with at least one re-post. We examined the percentage of messages with re-posts in different message categories. Then we compared histograms of the number of

re-posts across different categories. Following those comparisons, we did a regression analysis to inspect the factors that may influence the number of times a message is re-posted.

When a message is re-posted, it is broadcast to the followers of the re-post author. Those followers then can in turn re-post the message again. Thus the information dissemination follows a tree-like structure, which we call "re-post tree".

In order to further understand the re-post process over time, we reconstructed part of the "re-post tree" (we do not have the complete re-post data due to the limited search function of the Sina-Weibo system). Then we examined the depth of the re-post trees and how fast a message can transfer in the re-post trees. The exploration revealed interesting patterns in the dissemination of disaster-related information.

ANALYSIS RESULTS

Content Analysis
Following our iterative coding process, we developed a classification scheme for disaster-related microblog messages. This classification scheme provided a framework for a basic understanding of the potential roles that a microblogging system might play during the disaster response. We identified several major categories of content: Informational Messages which includes Situation Updates and General Yushu Earthquake Related messages, Action-Related, Opinion-Related, and Emotion-Related messages. Each major category corresponds to a different role the microblogging system may play in disaster response. Table 1 shows a summary of the categories and their sub-categories.
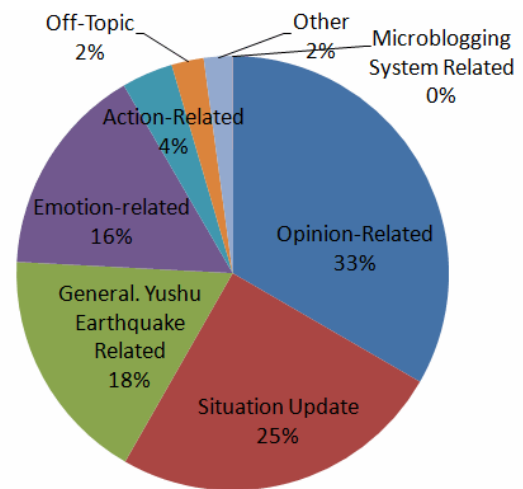

Figure 2. Category Distribution of Microblog Messages

We applied the classification scheme to all 4618 sampled microblog messages (Figure 2). Most messages fall into the five major categories: there are 1540 (35%) opinion-related messages, 1151 (26%) situated update messages, 811 (18%) general Yushu Earthquake related messages, 729 (17%)

emotion-related messages, and 177 (4%) action-related messages. Besides that, there are 111 off-topic messages, 97 messages on earthquakes but not on the Yushu earthquake, and 2 microblogging system related messages.

Category	Description
Informational Messages	
Situation Update	Providing factual information about what was happening in the earthquake area. Such information improves situational awareness in disaster response.
General Yushu Relief Related	Any other Yushu relief related information, including donation, mourning activities, and touching stories.
Other	Other earthquake related information
Action-Related	
Requesting Help	Requesting help or describing the needs of earthquake victims or rescuers. Such information often leads to others' responses or actions to address the needs or problems.
Looking for Missing People	Seeking or publishing information about missing people, especially family members or friends.
Proposing Relief Actions	Proposing relief actions to the general public
Relief Coordination	Coordinating relief efforts. Organizing actions among a group of Sina-Weibo users
Opinion-Related	
Criticizing	Criticizing government agencies, organizations, or individuals
Suggesting	Providing suggestions to the government, rescue agencies or individuals
Other opinion	Appraising; or making comments without explicit appraisal or criticism
Emotion-Related Expressing personal feelings such as anxiety, sadness, anger, pride, confusion, etc. Or Providing social and emotional support, including mourning, blessing, comforting, encouraging and expressing concerns for victims.	
Microblogging System Related Suggesting or reflecting on how Sina-Weibo should be used in disaster response.	
Off-topic Messages irrelevant to the earthquake.	

Table 1: Microblog Messsage Classification

Next we take a closer look at some major categories:

Informational Messages

Situation Update. Situation update is of great value in disaster response. It may improve situational awareness for both the general public and decision makers. This subcategory contains posts about what was happening in the earthquake area. Those posts might be from primary sources sent by the local residents, reporters or rescuers in the area, or by authorized information sources such as the national television. But most of the posts were from secondary sources – people forwarded messages that they received from primary sources. The content of those messages mainly contains people's experiences or observations about what was happening in the earthquake area, including extent of damage, official death/injury reports, status of rescue efforts, advice for rescuers and reporters, road conditions and weather reports. Some examples are "a 7.1M earthquake rocked Tibetan Autonomous Prefecture of Yushu"; or, "at least 400 dead and many injured". Many posts shared pictures and reports, for example, "life after catastrophic earthquake in Qinghai" with a hyperlink to the source.

General Yushu Relief Related. Other than the situation update information, the category of informational messages also contains general Yushu earthquake related information, covering people's activities outside the earthquake area. Topics include general relief activities such as donations, and key events, such as the national mourning day.

Action-Related

Although only a small portion of the microblog messages were action-related, the absolute number of those messages was not small. Such messages usually got a large number of re-posts as we will show in the *Trend Analysis* Section. Action-related messages exemplify an important role that the microblogging system may play in disaster response. Such messages may lead to direct actions in disaster relief.

Seeking or Offering Help. While related to "Situation Update", posts in this sub-category pled for responses and actions from the microblogging community or the whole society. And those messages were often more specific on needed material for rescue and relief, such as medical items, rescue equipment, daily supplies, etc., for example, "the temperature in Yushu is dropping below freezing point, and we are in urgent need for: excavators, tents, bedding, and clothes. Please contact: 1535298xxx0, 1535298xxx2". Other messages asked for needed specialized people including doctors, translators who speak both Mandarin and Tibetan, for example, "Xining hospitals need Tibetan translators". There were also some people who described their expertise (for example, doctors) and expressed a willingness to help.

Looking for Missing People. Some posts were looking for missing people, especially family members or friends, for example, "looking for Yonggang Hu, a teacher from Minzu University of China. He is on a field trip with students in Zaduo, Yushu. We lost contact with him after the

earthquake. Please call 1365557xxx5 if you have any information". There were also posts reporting people who were found safe or dead, for example "Wang Chongchong has been found safe!"

Proposing Relief Action. These posts were proposing specific actions to the general public, for example, to donate money through certain charity organization: "please donate through the Red Cross by going to this URL."

Relief Coordination. These posts tried to coordinate relief actions among groups of people. For example, to notify some group or person's responsibility or to notify time and place of certain activities.

Opinion-Related

People post microblog messages to express opinions on earthquake related issues. The majority of the posts in this category criticized government agencies, organizations and individuals on issues such as earthquake prediction, environmental protection, and budgets on earthquake rescue and relief, etc. For example, "Why did so many schools collapse in the quake? The government should raise the quality standards!" There were also posts praising rescuers for their valiant and selfless efforts. Some users used the system as a platform to provide suggestions to certain government agencies on issues such as relief efforts, allocation of the donated money, and reconstruction of the schools damaged during the earthquake. For example, a widely re-posted message by a famous writer suggested "building a Yushu memorial hall in the 2010 Expo".

Emotion-Related

People post microblog messages to provide social or emotional support or expressing personal feelings, for example, "Bless the people in Yushu!" was a very frequent post. Most posts in this category were mourning, blessing and encouraging earthquake victims. Such posts increase around April 21th which was designated as the national mourning day. People also expressed their own feeling such as anxiety and sadness: "I cried several times while watching the news. The children there are so pitiful!"

Microblogging System Related

Interestingly, we found two posts that gave suggestions about how people should use microblogging in response to the earthquake. One post suggested that "people should not use the 'Yushu Earthquake Help Seeking' tag if the post is only emotional related, such as mourning, blessing or encouraging the victims." The author of the post then gave the reason: "The abuse of this tag will prevent real 'help seeking' posts from getting to the intended audience". Another post told people that they could "use the microblogging system to look for missing family members or friends, or to seek and offer help".

In summary, the content analysis revealed several potential uses of microblogging during disaster response, including situation updates, relief action requests and coordination,

opinion expression, and emotion expression. We will discuss possible ways to harness those functions in the *Conclusion and Discussion* section.

Trend Analysis

The trend analysis revealed the attention and activity shift during the different phases of emergency response. We will first examine the overall posting and re-posting activities, and then examine the trends of different message categories over time.

Overall Trend

We analyzed the microblog message trends using our collection of the 93,643 Yushu earthquake related messages from a 48-day period after the earthquake. We counted the number of messages posted each hour during this period (the red line in Figure 3) and the number of messages with at least one re-post each hour during this period (dotted blue line in Figure 3). We can see that the message number peaked immediately after the earthquake occurred (7:49am, April 14) and gradually dropped from April 14 to April 20. Volumes surged again on April 21, which was the national mourning day for the earthquake victims. The number of messages continued to decrease after that, except for two small peaks on May 12 and May 29, which were due to the second anniversary of the 2008 Sichuan earthquake and an aftershock, respectively.

Among the 93,643 microblog messages, 18,654 (20%) were re-posts. The trend of the re-posts is similar to the overall message trend. There is no significant change on the percentage of re-posts in all the messages during this period.
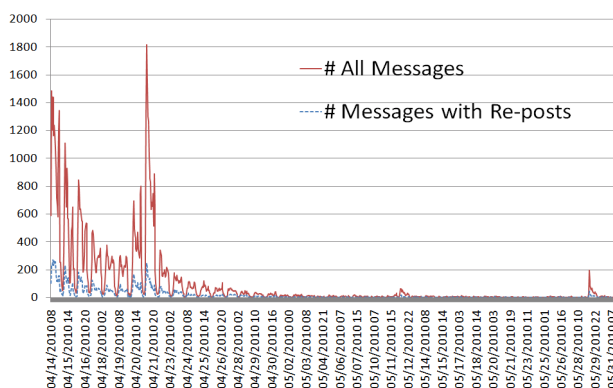

Figure 3. Trends of Earthquake Related Messages

Different Types of Microblog Messages

To answer the question: "do people post about different issues during different phases in emergency response?" we drew the trends of different message categories based on the 5% microblog messages classified in our content analysis (discussed in the *Content Analysis* Section). Figure 4 shows the trends of five major categories: emotion-related, opinion-related, situation update, action-related and general Yushu Earthquake related information. We observed attention and activity shift in this graph. The situation update messages peaked immediately after the earthquake

and dropped afterwards, as expected. There was a small peak of situation updates on May 29 because of an aftershock. The emotion and opinion curve also peaked after the earthquake occurred. However, unlike the situation update curve, the emotion curve also peaked on the national mourning day (April 21) as it was a time for people to mourn their losses and reflect on the catastrophe. The action curve gradually increased after the earthquake and reached its peak a day after the earthquake when the rescuers started to send out requests for specific kinds of help. It also slightly increased during the national mourning day because there were mourning activities calling for public participation. The general Yushu earthquake related messages mainly contain information about earthquake relief activities outside of the earthquake area, such as donation activities. Such activities started one or two days after the earthquake and led to a small peak on April 16. During the national mourning day, such efforts or reports of such efforts reached a peak.

The category trends revealed the shift of attentions and activities during disaster response: immediately after the disaster happened, the biggest portion of disaster-related messages were situation update as people were eager to learn about the catastrophe. There was a short delay before people sufficiently understood the situation and sent out specific requests for help, or participated in various relief efforts. Expression of emotions or opinions surged with key events such as the national mourning day.
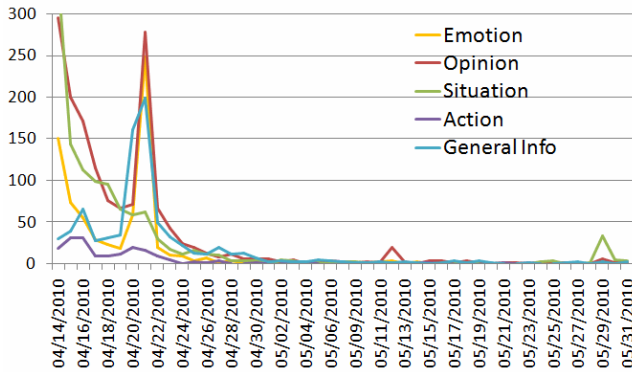

Figure 4. Category Trends (5% Sample)

Information Spreading Analysis

Information is disseminated in microblogging systems by posting and re-posting. How widely and how quickly disaster-related messages can spread greatly affects the value of microblogging systems as an information source and communication channel in disaster response. In this study, we attempted to answer the following questions: Which category of disaster-related information is more likely to be re-posted? What do the re-post trees look like? What factors influence the re-post number – the number of times a message is re-posted?

Re-posting in Different Microblog Messages Categories

We first examined messages with re-posts in the five major message categories: Situation Update, Opinion-Related, Emotion-Related, Action-Related, and General Yushu Earthquake Information. Among the 4618 randomly selected messages, 898 (19.4%) of them have been re-posted. Table 2 shows the percentage of messages with re-posts under each message category.

	Emotion	Opinion	Situation	Action	General
All Messages	729	1540	1151	173	811
Messages w/ Reposts	126	226	279	44	186
%	17.3%	14.7%	24.2%	25.4%	22.9%

Table 2. Percentage of Messages with Re-post

A CHI-Square test comparing the category distribution of messages with re-posts and the category distribution of the 4618 randomly selected messages shows that the two distributions are significantly different ($p < 0.001$). The percentage of messages with re-posts is much higher in the action-related and situation update categories than in the opinion-related and emotion-related categories.

Figure 5 further shows a box plot of the re-post number of each message under different categories. The Action category clearly has higher median re-post number than other categories. We can also see that there are outliers (messages that were heavily re-posted) in all the categories. A frequency distribution analysis on re-post numbers in different message categories indicated that all the categories have the distribution approximately close to the power law distribution, as shown in Figure 6.
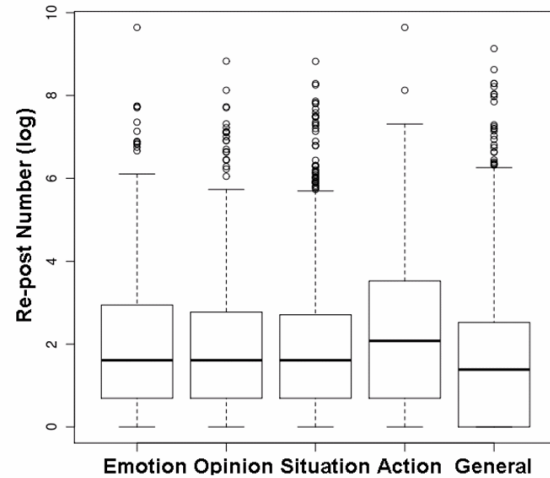

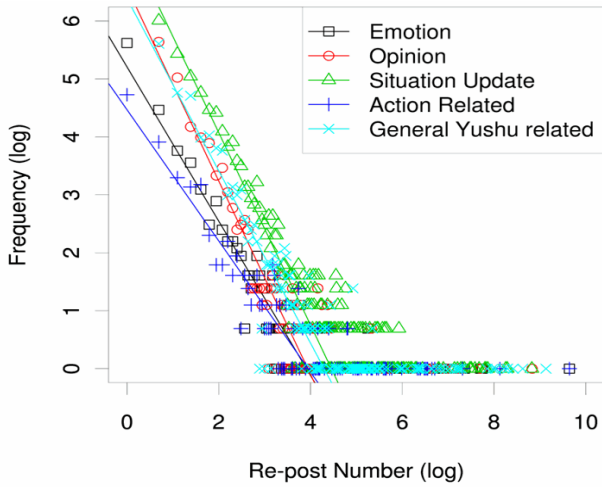**Figure 5: Messages' Re-posts Num under Different Categories**

Figure 6: Frequency Distribution of Re-post Numbers

We also looked at whether being a VIP affected how many times that person's messages were re-posted. Based on all the re-posts we collected, we found that the median of the re-post number is 5 if the original message was from a VIP user, while the median is only 1 if the original microblog message was from a general user. Next, we want to know if the difference in re-post numbers is just caused by the difference in the number of followers (e.g. VIPs usually have more followers than general users) or due to people's different perspectives on VIPs and non-VIPs (e.g. VIPs may be more trustable as they were certified by Sina).

Based on our exploration, we suspected that the following factors might influence the re-post number of a message: the category of the message, the number of followers of the author, and whether the author is a VIP member. We conducted a regression analysis on these factors. We found that the number of followers is the dominant factor (beta=.650, sig.=.000, adjusted R square by this single factor is 0.353). Being in the "action" category or being in the "opinion" category also affects the re-post numbers. However, their impact is much less strong than the number of followers (the adjusted R square only increased 0.04 by adding the "action" and "opinion" factors). Finally, being a VIP is also a significant factor in predicting the re-post numbers. However, its impact is even less strong compared to the above factors (the adjusted R square only increased 0.01 by adding the VIP status factor). This result showed that the number of followers is the key factor on re-post numbers. The effect of VIP status is more likely related to the number of followers the VIPs have attracted (the Pearson Correlation between the log of one's number of followers and whether one being a VIP is 0.755).

Re-post Trees

In a re-post message, the original author is mentioned by their user name followed with "@", and separated from re-post authors by "//". Each re-post message reveals part of the re-post tree structure from the original author to the current re-poster, including all intermediate re-posters on

the path. The Sina-Weibo system only allows the retrieval of a small portion of re-posts which contain the search keywords in the comments the re-poster added to the original message. Therefore, we could only reconstruct part of the re-post trees. Figure 7 shows a random sample of those partially reconstructed trees. Although those partially reconstructed trees missed many nodes and links, we can still see that many re-post trees contain multiple re-post chains with multiple re-posters on the path.
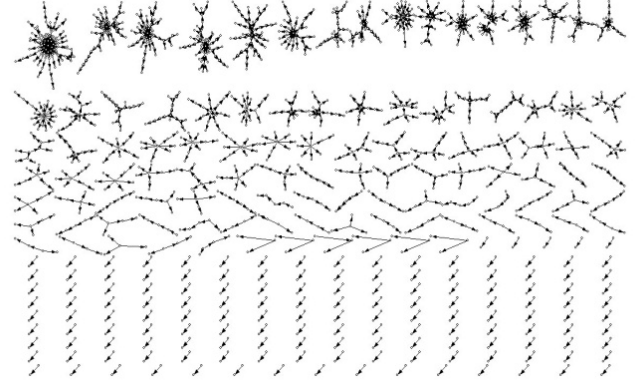

**Figure 7. Random Sample of
Partially Reconstructed Re-post Trees**

We constructed 1925 relatively complete re-post trees from all the data we collected. These trees give us opportunity to study how far and how quickly a disaster-related message spread in the network by re-posting.

Type	Emotion	Opinion	Situation	Action	General
Average depth	1.52	1.56	1.49	1.82	1.47
Max depth	8	10	21	14	15

Table 4. Depth of Re-post Trees

Table 4 shows the average depth and the maximum depth of re-post trees under different message categories. Re-post tree depth is an indicator of how far a microblog message could spread in the microblogging community. The table shows that action-related messages are more likely to have longer re-post chains in their spreading (T-tests between different categories showed that the depth of re-post trees of action-related messages is significantly longer than that of other types of messages).

Figure 8 shows the average amount of time it took for a message to reach the next level in its re-post tree. To make the analysis more reliable, the figure shows only data points where we have more than 100 samples of re-posts. The increasing curves in Figure 8 show that, in general, the further a message spread in a re-post tree, the more time it takes on each step. The figure also shows that situation update messages spread faster in re-post trees than other types of messages, while opinion-related messages spread

slower in re-post trees than other types of messages. However, the depth of re-post trees (Table 4) and the average re-post number on each original message (Figure 5) under the opinion-related category were not less than the those under the situation update category, which implies that the speed of information spreading may not affect the scope of information spreading.
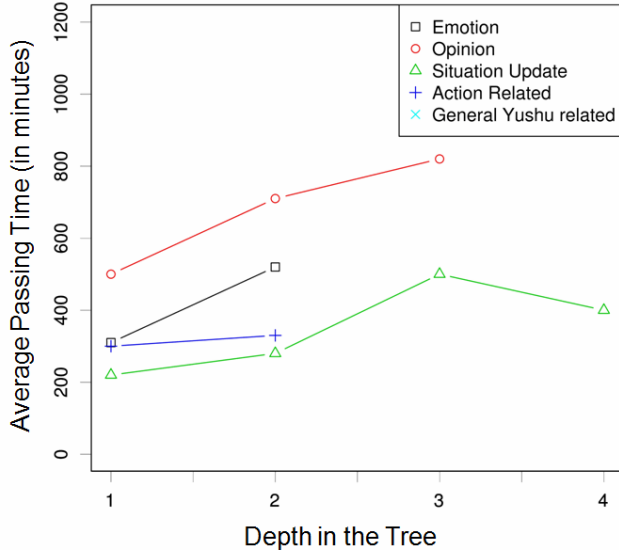

Figure 8. Information Spreading over Time

CONCLUSION AND DISCUSSION

In this paper, we analyzed various aspects of information dynamics in a popular Chinese microblogging system (Sina-Weibo) in response to the 2010 Yushu Earthquake, including the type of messages posted, how people's attention on different topics shifted over time, and how messages were re-posted and spread.

We found that people used the microblogging system for four major purposes during the disaster and its aftermath: situation update, opinion expression, emotional support, and calling for action. These different message categories showed different trends and different dissemination patterns during the disaster response period. The trends suggested an attention shift among different issues during different phases of disaster response. They also revealed a propensity to spread certain types of information (i.e. action-related messages).

The use of a microblogging system as a source for situation update in disaster response has been recognized by previous studies [25]. Our study supports such findings by showing that a large amount of situation update messages were posted immediately after the disaster and they spread faster in the network than other types of disaster-related messages. In addition, we found that an overwhelming number of situation update messages were second-hand. Therefore, a carefully designed filtering mechanism is needed for users to distinguish first-hand and/or authorized messages from the second hand messages.

Action-related messages were typically related to disaster rescue and relief efforts. People used the social platform to disseminate disaster relief related information and to call for and coordinate actions, including requesting rescue and relief resources, organizing rescue and relief activities, and organizing donation campaigns. Our study showed that action-related messages did not appear immediately after the disaster happened. People need to gain sufficient understanding of the situation before they are able to organize or participate in any actions. Although the total number of such messages was small, people were more willing to re-post action-related messages. A more systematic evaluation of the effectiveness of such messages is needed.

Although emotion-related and opinion-related messages do not seem to be directly useful in disaster response, it is important to have such social interactions at a societal level in response to major disasters. People expressed depression, anger, sadness and they sought for emotional help. At the same time, the community members exchanged opinions on many disaster-related issues. It is part of a process where the society forms mass opinions and social norms. For example, both emotion-related and opinion-related messages peaked on the national mourning day, which provided a chance for the community to mourn and reflect on the disaster.

Different from most previous works that have been based on Twitter in a North American based and English-speaking culture, our study is based on the largest microblogging community in China: Sina-Weibo. Although we have not been able to conduct a cross-cultural comparison between Twitter and SINA-Weibo, we believe this work can open a new window into a different socio-cultural system.

One limitation of this study is in our data collection. We were only able to collect microblog messages with two keywords in the content analysis, which could make our content analysis biased toward some specific categories although we have not been able to identify any systematic bias. Also, we have only partial data in our re-posting pattern analysis because of the limitations of the microblogging system, which may have affected the results of information spreading analysis. We hope to collaborate with Sina-Weibo to get the complete data set in the future.

Our future research agenda includes 1) a continuation of the to study to understand how disaster-related information is spread in microblogging systems, especially with respect to identifying factors that affect the information diffusion process. These factors include network characteristics, message content, post author's personal interests, and location; 2) a study of emergency and disaster taxonomies to understand how microblogging systems respond to different types of events; 3) a comparison of microblogging usage in disaster response in different socio-cultural systems. In particular, we would like to compare Sina-Weibo and Twitter, which are two large microblogging

communities in two very different socio-cultural systems. Besides basic comparisons on demographic features, message content, and message trends, we are interested in understanding how social structures affect information spreading, such as the impact of community structures in the microblogging systems on information spreading, and the roles of authorized accounts such as government agencies and news agencies in information spreading and rescue coordination.

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