

TWITTER AS A RAPID RESPONSE NEWS SERVICE: AN EXPLORATION IN THE CONTEXT OF THE 2008 CHINA EARTHQUAKE

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ABSTRACT

Micro-blogging websites (such as twitter), a new information channel, was widely reported as outperforming the mainstream information channels in numerous ways during the massive 2008 China earthquake, including beating the first official mainstream news released from the USGS to report the initial tremor (BBC May 12 2008). According to Twitter.com, there have been noticeable spikes of twitter usage during disasters and other large events, serving as an extremely powerful and effective fast response news service. This raises some important exploratory questions: What kind of information can micro-blogging provide regarding disaster news? Of what quality is the information provided by micro-blogging? Can the modern communication tool – micro-blogging, replace the mainstream media information channel or merely supplement it in distributing disaster news? How do twitter (and other micro-blogging services) compare with the mainstream information channels during the different timeframes in terms of information quality and collective intelligence? For this research paper, we will use Twitter as a proxy for micro-blogging in general, the mainstream media information channel as the benchmark, and the massive 2008 Sichuan earthquake as our research subject. At the time of the Sichuan earthquake, Twitter was universally available in the China mainland. The aim of this exploratory study is to shed some light on how micro-blogging can provide integrated and speedy information regarding disaster news.

1. INTRODUCTION

On May 12, 2008, at 14:28 hours, a magnitude 8.0 (CSB) / 7.9 (US Geological Survey (USGS)) earthquake struck the Sichuan province in China (Xinhua May 18 2008). This later turned out to be one of the world's largest natural disasters in recent history. This was also one of the first large-scale natural disasters to occur since the social networking website Twitter, which was created in 2006, became a widespread communications channel. In fact, information was being disseminated by Twitter a full 3 minutes before the USGS had the first report of the earthquake (BBC May 12 2008; SearchEngineLand News May 12 2008). Subsequent to the earthquake, cellular networks were overloaded. Communication with channels accessible via text messaging such as Twitter played an enormous role in helping news be communicated from and to the victims of the disaster as it was often the only communication means available.

Micro-blogging services such as Twitter, have the ability to distribute information very quickly, and possess a unique role in assisting victims in numerous ways during the aftermath. This brings about many exploratory questions: What is the role of micro-blogging as a rapid disaster news service? What type of information quality is provided by micro blogging during different timeframes? Due to the fact that the mainstream media channel provides the news casting function for the audience, we will use the existing mainstream media channel as the reference point for comparison in our paper. The results of our study will have implications regarding whether the modern communication tool – micro-blogging, could replace the mainstream media information channel or merely supplement it in the

manner of distributing disaster information. In prior literature, whenever some new information technology has been studied (such as B-to-C commerce), content analysis and comparisons have been used for research purposes (Kim et al. 2005). We will adopt a similar approach in our paper, using the mainstream media information channel as the benchmark.

The concepts of information quality as well as ‘collective intelligence’ will be utilized to explore micro-blogging in terms of information quality regarding fast disaster news dissemination and understand how effective it is in adding value through the process of collective intelligence. To the best of our knowledge, this is the first research directly examining the information quality of web 2.0 information channel over time subsequent to a major disaster. The implications of this study are that it can allow emergency responders to choose which information channel to focus on at different times during the disaster response. The remainder of this paper is organized as follows. The background is described in part 2. The literature review is discussed in part 3. Analysis and our findings are shown in part 4. We conclude with discussion and future research in part 5.

2. BACKGROUND: TWITTER IN CHINA AND THE CHINA EARTHQUAKE

2.1 Twitter and Micro blogging in China

Created in 2006, Twitter is one of the most popular micro blogging sites in the world. This social networking website allows anyone to create an account and instantly broadcast their thoughts to the world. Users can both send and receive messages via twitter.com, as well as by other means such as SMS text messaging, and numerous cell phone and desktop applications. ‘Twitter has experienced incredible growth in usage, with total time spent on the website increasing 3712% year over year’ according to a June 2009 Nielsen Online survey (Nielsen Jun 2 2009). This does not include mobile usage. Twitter includes multiple functionalities such as ‘following’ other users. This allows people to see a user’s comments in nearly real time via the web or an application. While messages are limited to a mere 140 characters, users are able to immediately broadcast anything to the world with any computer or cell phone with internet capabilities.

With ease, and immediacy of use, micro-blogging is a potentially appealing tool in the case of emergency news dissemination. Consuming low bandwidth in an environment where infrastructure may not be fully intact, information can be easily and quickly disseminated for use by those who need it most. As described in USA Today on May 19, 2009, ‘a fast-moving network of text messages, instant messages and blogs has been a powerful source of firsthand accounts of the disaster, as well as pleas for help and even passionate criticism of rescue efforts’. Twitter founder Jack Dorsey told AFP in a 2007 interview that “inspiration for the service came from his experience writing software for courier and emergency service dispatchers that need to route people between locations”. Twitter designer Biz Stone recalled an instance of receiving notice about an earthquake in California via twitter just before boarding a train last year. It was there that he first envisioned its potential in emergency response as a communications tool (AFP May 12, 2008). Many people use twitter to check the most recently updated news in emergencies and other breaking events.

Approximately a year after Twitter launched and was gaining a small, but growing base, China saw a number of home-grown micro-blogging websites began to appear. This includes sites such as Digu, Sina, and Fanfou. In addition to messages having a small character limit, these sites began to incorporate other features such as embedded video and pictures. These and other chat providers also allow the ability to also update personal microblogs simultaneously. ‘The people who run these Twitter clones in China argue the sites employ features which attract Chinese to socialize and share information in an easier and faster way’ (CNN Dec 27, 2009). A Twitter clone, QQ, ‘is the 9th largest web property in the world and has over 570 million registered users for their instant messaging service of its IM

service' (www.qq.com). Another micro-blogging service is called TaoTao, and is in direct competition with other Chinese services (CNN Dec 27, 2009). According to a study from San Francisco-based Netpop research, while only seventy-six percent of broadband users in the United States utilize social media features, more than 90 percent of Chinese broadband users do so. (CNN Dec 27, 2009). The Chinese market is highly receptive to these text based web2.0 communications that are now becoming pervasive in society.

On Jun 2 2009, Twitter was blocked in mainland China. Many of the early Chinese micro-blogging pioneers with similar functions were also blocked, yet unlike Twitter which is still blocked; most had soon found their way back online. For instance Fanfou, reached nearly 1 million registered users by the end of June 2009 (ReadWriteWeb Mar 5, 2010). Meanwhile, China's 'Great Firewall' has enough holes to allow some Chinese netizens to use Twitter itself versus one of the micro-blog alternatives' (CNN Dec 27, 2009). Michael Anti, a Chinese Twitter user with over 10,000 followers notes, "It is a risk of course". Yet, "the Twitter community is booming and is expanding" (CNN Dec 27, 2009). According to the 2010 China Microblog Overview by Buzzle (Feb 2010), "Twitter is still very popular with a sub-section of Chinese users who are able to cross the Great Firewall of China". They additionally make note of various rumors about the possibility that Twitter is attempting to develop technology to allow all users to cross the firewall, allowing them further development in China (Buzzle Feb 23, 2010).

While twitter only makes up a subsection of the micro-blogging universe in China, at the time of the Sichuan earthquake, it was fully accessible, and still one of the more widely used micro-blogging services in China. As tweetscan was able to provide us an excellent and full historical search ability of the timeframe around the earthquake on twitter, we were able to obtain a rich data source to analyze and use as a proxy for micro-blogging.

2.2 Sichuan Earthquake and Twitter

The Sichuan earthquake was China's largest natural disaster in 30 years. Sichuan suffered an enormous loss with 87,587 reported killed or missing and over 374 thousand injured. Further, 5.36 million buildings collapsed and over 21 million were damaged (USGS May 2008). The communication networks completely went down in Sichuan province and were also disrupted in other areas after the quake (AFP May 12, 2008). "Fixed line phone services were heavily damaged in most neighborhoods", Xinhua quoted one of China's largest mobile service providers as saying. Even China's Earthquake Department website, a key point for information about the earthquake, was inaccessible (AFP May 12, 2008). Information about the massive earthquake was spread through text messages, instant messages, and micro-blogging services, such as 'twitter'. As the cellular networks were overloaded, these text based communications played an enormous role in helping the victims of the disaster.

Agence France Presse (AFP May 12, 2008) reported *"the world had real-time news about China's massive earthquake as victims dashed out "twitter" text messages while it took place, in what was being touted that Tuesday as micro-blogging outshining mainstream news. As the earth shook with tragic consequences, people in the parts of China that felt the quake used their mobile telephones to send terse messages using the service provided by the San Francisco-based Twitter Inc. News of the deadly catastrophe reached Twitter devotees such as blogger Robert Scoble in San Francisco even before the massive temblor, which killed more than 12,000 people in Sichuan province, was reported by news organizations and the earthquake-tracking US Geological Survey".* Xiao Qiang, a journalism professor at the University of California, Berkeley, commented on USAToday (May 19 2009): *"All the major online communities, bloggers, all are very eager to help. It's quite amazing. I haven't seen anything like that, the freedom and the participation, how much the average Internet netizen wants to help".*

According to O'Brien (2008), who started a new project aiming to investigate the newsroom of the future, "*The beauty of Twitter is that it enables: An instant, virtual, citizen journalism newsroom that immediately posts thousands of updates*". Twitter is very good at distributing breaking news. It has the potential to improve the overall reporting and flow of information for everyone. It combines people who are on their computers, the ones on the move with cell phone and PDAs, twitter facilitates real-time group communication that never existed before (Mills et al. 2009). That is why one twitter blogger commented that "*This event has the potential to bring mainstream media into the Twitter world*" in an interview given for AFP (May 12, 2008).

3. LITERATURE REVIEW: INFORMATION QUALITY AND COLLECTIVE INTELLIGENCE

3.1 Information Quality

Information quality (IQ) has been defined as a measure of the "fitness for use" of information (Wang and Strong, 1996). The quality of information depends on who and how the information is being used. Data meeting the needs of a particular user would be high quality. Data which is of high quality for one user may not necessarily be high quality to another depending on their different needs and perceptions. Since it is a very difficult concept to be captured, defined, and measured, over the last decades, many IS researchers have intensively studied the definitions and taxonomies of IQ in different dimensions, contexts and applications. They feel IQ should be treated as a multi-dimensional concept (Wang and Wang, 1996; Wang and Strong, 1996; Huang et al., 1999; Helfert et al., 2009). Parker et al. (2006) evaluated a number of IQ frameworks in order to identify common elements, differences, and missing elements of such frameworks. Parker et al. (2006) has adapted a framework of thirteen information quality dimensions, that includes: accessibility, accuracy, appropriateness and so on.

Delone and Mclean (1992; 2003) also incorporated information quality as one of the determinants that affect the success of information systems in the IS Success Model which they proposed. In their work, information quality was measured by accuracy, timeliness, completeness, and relevance of the information provided. Helfert et al. (2009) also concluded that accuracy, timeliness, accessibility (availability), completeness, consistency, and interpretability should be considered as the most important IQ dimensions.

Pipino and Wang (2002) described a subjective and objective assessment of data quality and presented three functional forms for developing objective data quality metrics, which were simple ratio, min or max operation, and weighted average. Simple ratio measures the ratio of desired outcomes to total outcomes (Pipino and Wang 2002). This ratio ranges from 0 to 1. 0 represents the least desirable outcomes and 1 represents the most desirable outcomes (Pipino and Wang, 2002). The four main dimensions described in Pipino and Wang (2002)'s research include *timeliness*, *accessibility*, *accuracy*, and *completeness*.

Timeliness was defined as the extent to which the data is sufficiently up-to-date for the task at hand by Pipino and Wang (2002). Only if the information is up-to-date, is it representative of the current states of the situation. In the context of emergency response, timeliness is one of the most important components of information quality. The initial hours following the disaster are the most important for emergency responders. Every single minute counts, since that is when lives will be saved and lost. We are particularly interested in how quickly micro-blogging can distribute information in disaster, thus we will focus on studying the timeliness aspect of information quality. We will look at both of the positives and negatives regarding timeliness as they pertain to both the mainstream information channel and twitter.

Accessibility (availability) was defined as the extent to which data is available, or easily and quickly retrievable (Pipino and Wang 2002). As mentioned by Vandenbosch and

Higgins (1995), accessibility is an important dimension of deciding the use of an information channel. Accessibility of information was a major factor in the Sichuan earthquake. In the area around the epicenter, the infrastructure was devastated. It was not until towards the end of the first month where communications were fully restored. Cell phone conversations were impossible. People had no access to television or the internet. The main mode of two-way communication for most people was text messaging, whose low bandwidth did not place as large of a load on the fragile network. Twitter's ability to be used via text message and the 140 character limit which further constrains its required bandwidth, has made it an ideal communication tool in such a situation. Twitter's structure also allows groups of users to be created which directly broadcast information amongst each other in real time. At the same time, other information channels remained inaccessible in the quake zone (such as Wenchuan County) for weeks.

Accuracy (free-of-error) was defined as the extent to which data is correct and reliable (Pipino and Wang, 2002). Accuracy is vitally important in order for resources to be properly and most effectively allocated to quickly assist the maximum number of people. Erroneous information can waste precious minutes and seconds. A mistaken location or incorrect assessment of severity causes resources to be sent to an area in less need of aid, or perhaps where it is not needed at all. The inherent characteristics of micro-blogging allow it to provide information, and simultaneously confirm it through the power of collective intelligence, which will be discussed later in the paper. Single incorrect reports are bound to occur and will in fact be common. However these erroneous reports will be overwhelmed by repeated reports of the correct information from other sources. This allows for increased accuracy over a short period of time.

Completeness was defined as the extent to which data is not missing and is of sufficient breadth and depth for the task at hand (Pipino and Wang, 2002). Completeness is also extremely important in allocating emergency response resources. As in all decision making processes, a more complete picture of the situation allows for better conclusions being drawn. Resources can again be easily misallocated without completeness. In the example of the earthquake, perfectly immediate and accurate information about a situation requiring assistance could have been provided to emergency response, but if that information was incomplete, for example, some areas were completely inaccessible, time and resources could be wasted. Again, the power of collective intelligence allows micro-blogging to provide a superior overview of the situation, and a greater degree of completeness. Similar to a wiki, while a single entry provides but a small sliver of the overall picture, thousands of entries together can provide a grand overview.

3.2 Collective Intelligence

Weiss (2006) indicates that as far back as 1968, computer visionaries foresaw the possibilities of utilizing computers for cooperative purposes in allowing people capable of solving specific problems to share their ideas. Gregg (2010) commented "A collective intelligence application is one that harnesses the knowledge and work of its users to provide the data for the application and to improve its usefulness". Web 2.0 is how the most hyped examples of collective intelligence have come to be known Gregg (2010). These web 2.0 applications provide a platform or social network to facilitate communication, information sharing, and collaboration between its users. The concept of collective intelligence has been embraced in nearly all areas where extensive collaboration is a necessity. While computers were traditionally seen as a mere supportive tool, web 2.0 applications see them as a means to collect the wisdom of different groups of people to enable greater productivity and facilitate more meaningful decisions than are possible by individuals working in isolation (Gregg 2010). For example, anyone can add, supplement, and correct the definition and description

of a term in Wikipedia, a free, web-based, collaborative, and multilingual encyclopedia project (www.wikipedia.org). In other words, value is added through the contributions of information from a great number of people. A data collocation and analysis process is performed before the publication of an article in a newspaper or magazine. With twitters' 140 character limit, the collective intelligence is performed through multiple tweets that answer, describe, or supplement the same question and topic. In this paper, we also investigate the collective intelligence that tweets provide as compared to mainstream multimedia.

In the following section, we shall focus on the quality of information that micro-blogging can provide in distributing news about a disaster. We will concentrate on the following four well-identified information quality dimensions in the IS area: timeliness, accessibility, accuracy, and completeness. Additionally, we will investigate how effective twitter is in terms of 'collective intelligence'.

4. ANALYSIS AND FINDINGS

4.1 Timeliness

4.1.1 Data Collecting and Sample Characteristics

We used the Factiva database to obtain the sample of the mainstream news. We used 'China Earthquake' as the key words and specified the date range as between May 12 2008 to Jun 12 2009. It returned 1836 articles. We enabled the 'identify duplicate' option in order to avoid double counting. Factiva indicated 281 duplicate articles, leaving a sample of 1555 articles. 'Tweet Scan' is a search engine which enables search of Twitter messages in real-time (www.tweetscan.com) and which gave us access to the historical twitter database. We inputted the same search criteria as what we did with the Factiva database. 2130 tweets were found in our specified time period. By inputting similar criteria related to this earthquake, such as Wenchuan Earthquake, Sichuan Earthquake, Disaster, and Chengdu, more than 80,000 tweets were found. However, in order to more precisely be able to compare it with the mainstream information channel serving as the benchmark in this case, 2130 tweets were selected matching the search criteria "China Earthquake" exactly in our specified time period.

We classified the data into five buckets:

- 1) less than 1 hour after the earthquake
- 2) between the second hour to the end of first day
- 3) between the second day to the end of first week
- 4) the second week
- 5) between week three to the end of the first month

The statistics are shown in Table 1.

Timeliness	Mainstream (#)	Twitter (#)	Mainstream (%)	Twitter (%)
< Hour 1	9	433	1%	20%
Btw Hour 2 to End of Day 1	99	1071	6%	50%
Btw Day 2 to End of Week 1	597	327	38%	15%
The Second Week	448	111	29%	5%
Btw Week 3 to End of 1 month	402	188	26%	9%
Sum	1555	2130	100%	100%

Table 1. Statistics of Mainstream Articles and Tweets Gathered

4.1.2 Analysis of Timeliness Dimension

We observed 433 tweets in the first hour in contrast to 9 items from mainstream media; 1504 tweets during the first day in contrast to a mere 108 items from traditional media.

Immediately after the first day however, traditional media consistently provided more information, with 597 articles the rest of week one compared to 327 tweets, 448 articles week two in contrast with 111 tweets, and then 402 articles the remainder of the month, in contrast with 188 tweets. Figure 1 shows the comparison of timeliness with the two information channels. Figure 2 interprets the same data in a cumulative manner.

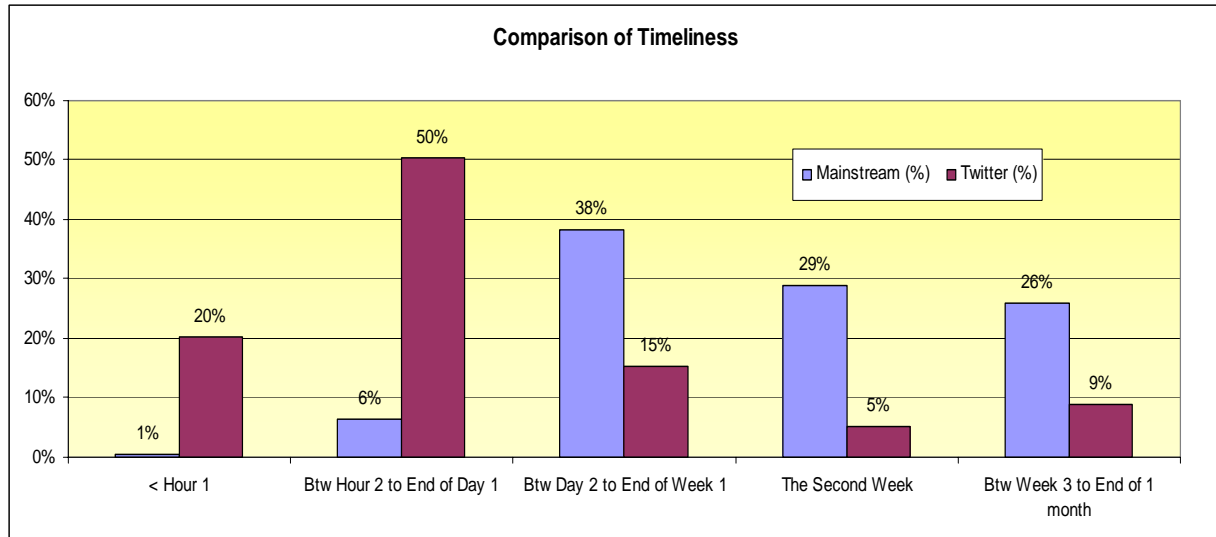


Figure 1. Comparison of Timeliness

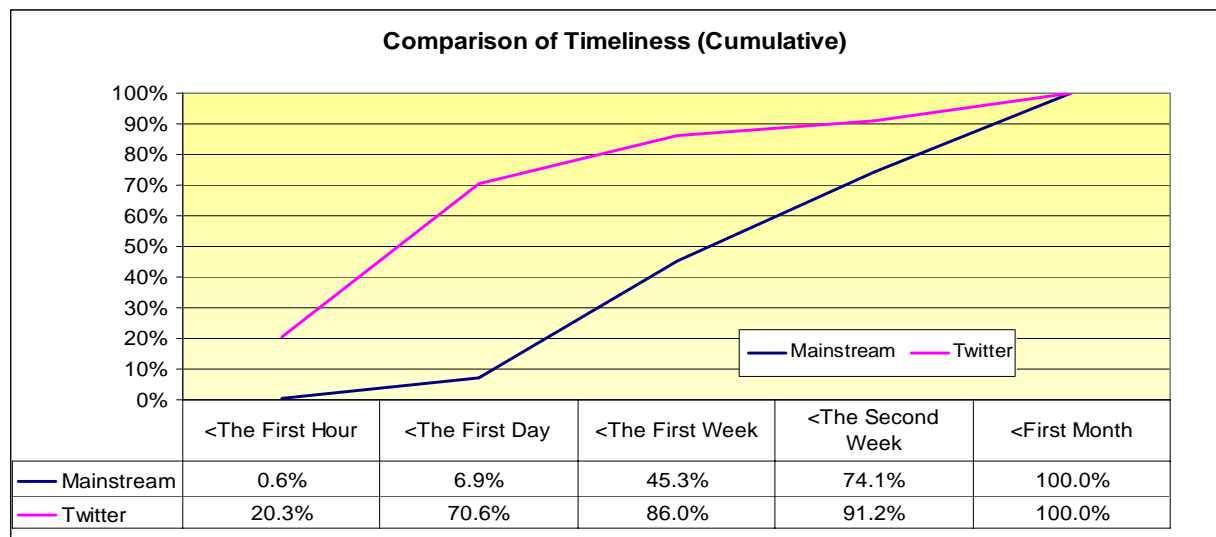


Figure 2. Comparison of Timeliness (Cumulative)

The initial minutes and hours following a catastrophe are the most important for emergency responders. These are the moments when lives will be saved or lost. 20% of the total information coming out of twitter was focused in the very first hour of the catastrophe. Meanwhile traditional media has a much more linear relationship between time and coverage of the event with about 1% and 7% of information coming in the first hour and the first day and it steadily remaining in the news in the weeks that followed. At the time when information knowledge is most critical, traditional media is extremely lacking compared to twitter. In fact, information was coming out of twitter a full 3 minutes before the USGS had the first report of the earthquake (BBC May 12 2008; SearchEngineLand News May 12 2008). Several people in China reported the earthquake via twitter while it was still going on.

The US Geological Survey (USGS) has people who work full time to watch for and observe earthquakes and tremors. They have seismometers monitoring movement in the earth in real-time. As noted by Search Engine Land blogger Danny Sullivan called it "absurd" to suggest that Twitter users knew of the Sichuan earthquake before the US Geological Survey, which uses seismic equipment positioned around the world to record such events, and then after a scientist's review sends out notices of the events (SearchEngineLand News May 12 2008). However in terms of this information being broadcast to the world for use by others, this was indeed the case.

Looking at twitter and the traditional media over the four weeks following the Sichuan earthquake, the majority of the media's coverage occurred on day two and later, while over 70% of the information coming from twitter was during the very first day, after which interest rapidly declined. Traditional media has the following drawback with regards to timeliness:

- (a) Slow to report.
- (b) Have to spend time checking sources before publishing.
- (c) More resources devoted to covering the aftermath.

Emergency responders and twitter users in fact have a similar timeframe of interest. While emergency response needs to gather information as quickly as possible, twitter users converse about what is happening immediately around them. They are both most engaged immediately. The following figure from tweetip.com demonstrates the immediate spike and decline in information coming from twitter by plotting in five minute segments, the number of tweets containing 'Earthquake China'. Our data obtained from tweetscan confirmed this behavior.

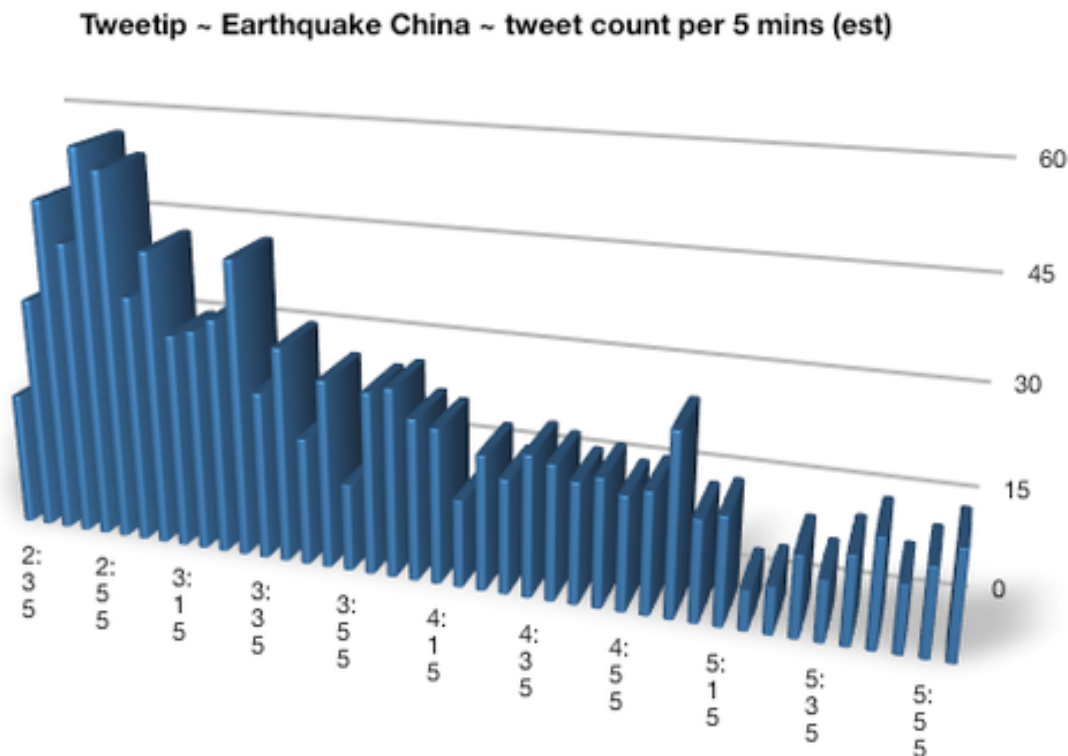


Figure 3. Tweet count per 5 minutes (adopted from Tweetip.com)

In emergency response systems, we should be taking advantage of the immediacy provided by twitter in getting information out to the masses. Such an easily utilized communication channel which broadcasts the information as quickly as twitter is unknown to us. Just a few minutes difference in getting information out can make an enormous difference in getting resources ready and gathering the response crew. We believe incorporation of twitter can dramatically help improve the information quality in terms of timeliness for emergency response system.

4.2 Accessibility

After the earthquake, the IT infrastructure was seriously damaged in the quake zone. According to EERI special earthquake report (Oct 2008), the electric grid was compromised throughout most of the disaster area. Every city in the surrounding area with the exception of Chengdu suffered power outages. Outages ranged from 10 to 20 days, with remote areas experiencing longer outages due to increased difficulty in accessing the areas in need of repair. Both hydro-electric, and coal powered electric plans experienced extensive damage and remained out of service for up to 60 days after the earthquake. Even the more populated and easier to access areas affected by the earthquake were without power for many days. Very few sources of information were available. Micro blogging and text messages which consume very limited bandwidth were often the only available information resources. Residents in the affected areas were not able to receive information from TV, radio, or Internet. Text based cellular communications were the only remaining ways to retrieve information. Mobile communications were not just beneficial for quake victims; it was also of great assistance to disaster response and recovery.

Steve Inskeep hosted a National Public Radio interview show on May 14, 2008. Some of its transcript is cited below. It once again shows how quake zone victims relied on the new information channel which consumes very limited bandwidth as the only communication way after the quake.

- *Host: People after rushing out in the streets of Chengdu to get out of buildings that they were afraid would fall were all on their cell phones sending text messages. That turns out to be the way that the first word got out about this earthquake, in a country where some 600 million people have cell phones.*
- *Quake Zone Resident: It (text messaging) is a very practical tool, and it's very busy. The user doesn't require any fancy phones, it works on everything, and it's very reliable. It's something like 99.9 percent arrival rates.*
- *Quake Zone Resident: People living in tents can't recharge their batteries. In the meantime it is very difficult to get the call through as the signals are very bad. Text messaging was the only way to go.*

We have gathered some news on the recovery of power, IT infrastructure, and cell towers from the related authorities. It serves as the basis for our following analysis.

- *Mobile service operator China Mobile's branch in Sichuan said about 2,300 local base stations stopped operating due to power shutdowns and transmission failures caused by the quake and three switching stations were overloaded. China Mobile has immediately started repairing affected facilities. Besides power disruptions and a surge in call volumes following the quake could have also slowed the cell phone network, they said. Call volumes were 10 times the normal level and the percentage of connections fell by half, China Mobile said (BBC Monitoring Asia Pacific May 12, 2008).*
- *According to Wall Street Journal News (May 22, 2008), China Mobile, like many other businesses that operate near the quake epicenter in Sichuan province, was jolted by the*

May 12 earthquake. At one point, 4,457 of its cell towers were out of service and phone traffic in Sichuan backed up with huge increases in calls. Yet the quick restoration of mobile phone coverage to all but a small portion of the quake zone is one of the hallmarks of China's strong response to the disaster. --- Initially, the mobile phone coverage was OK. A backup power source, designed for just such an emergency, kept the cell phone tower operational, though heavy phone traffic made it tough to get through sometimes. By the third day after the quake, however, the tower had used up all its juice, and cell phone coverage was officially out for the first time since the earthquake.

- *China Mobile (May 14 2008) said that by 8:00 CST on May 13, it had repaired 1,850 of the 4,457 base stations damaged in the afflicted region.*

- *Update from the Chinese Embassy (May 22 2008), 'So far, 23,117 of the 25,062 damaged telecommunications base stations have been repaired.'*

- *According to the State Electricity Regulatory Commission (SERC_1), as of 12:00 on May 25 (Sunday), electricity power supply had been restored in 12 Counties, including Lixian, but not yet in Beichuan County. According to the Ministry of Industry and Informatization, as of Sunday, May 25, public telecommunications services like mobile phone and fixed-line telephone had been restored in 62 of 109 towns and villages in quake zone, enabling local residents to communicate in different ways.*

- *According to State Electricity Regulatory Commission (SERC_2), as of midday June 9th, electricity power supply had been restored in 114 of the 135 towns and villages (in 7 counties of Sichuan Province) that suffered power outage as a result of the devastating earthquake which struck southwest China on May 12th*

Based on the news provided by the several authorities as shown above, we have conducted the following analysis.

1. Hour 1 and May 12: Once the power reserves of the cell towers were depleted, their ability to facilitate communication via text message and twitter also ended. Per China Mobile, 40% of the downed and damaged towers were back in service the first day. Because the text messages and twitter consume extremely low bandwidth, we make the assumption that if a cell tower is functioning, then both text messages and twitter are accessible. Due to the extremely high traffic where all volumes were 10 times the normal level and the percentage of connections fell by half per China Mobile, we are applying a 0.5 discount factor here to make a very conservative assumption that only 50% of the text messages and twitters go through if the cell tower is functioning. Anecdotal quotes above from quake zone survivors imply functionality of text messaging was far better than 50%, but we will hedge on the conservative side with our estimates.

Initial reports from China mobile indicated that 2300 of their base stations had been damaged. By May 13th, China Mobile was reporting they had already restored service to 1850 of the 4457 base stations which had gone out of service. The increase in base stations going out of service leads from the lack of electricity, and the back up power supplies quickly ran out of electricity. During this timeframe, both China Mobile and China Unicom (May 16 2008) made statements that half of their base stations had been affected. Not knowing exactly what time these 50% statements were made in reference to, we can estimate that China Mobile would have had between 4600 and 8914 base stations in Sichuan Province at the time of the earthquake. In the worst case, if the 2300 base stations were all knocked out immediately, accessibility would have been between 50% and 74% in the first hour. Multiplying by our 0.5 discount factor, we estimate an accessibility rate between 25% and 37%. For simplicity, and lack of detailed hour by hour numbers, we will assume this accessibility for the rest of the day.

During this period of time, use of traditional mainstream media is virtually impossible due to the complete lack of power.

2. May 13: It is important to note that the number of failed base stations continued to increase from the first day due to the backup power supplies being exhausted as noted in the Wall Street Journal article above. So while stations were being repaired, new ones were also going offline. Per China Mobile, 1850 of the 4457 damaged base stations were restored on May 13. This means 2607 base stations were still non-functional. This gives us accessibility of between 43% and 71%. Multiplying by our 0.5 discount factor, our estimated accessibility rate is between 21% and 35%. During this period of time, traditional media remains inaccessible.

3. May 22: The May 22nd update from the Chinese Embassy (May 22 2008) states '*So far, 23,117 of the 25,062 damaged telecommunications base stations have been repaired*' bringing us to 92% of the damaged stations being functional, and accessibility would be between 92% and 96%. Since the demand on cell towers was not as high as during the first couple days, we apply a 0.8 discount factor here, leaving us a range of between 74% and 77% accessibility. As shown by item 5 from the State Electricity Regulatory Commission, the mainstream accessibility rate is 57% on May 25. By assuming the recovery rate is constant, we can derive a 44% ($57\% \times (22-12)/(25-12)$) accessibility rate on the day of May 22.

4. May 25: Public telecommunications services like mobile phone and fixed-line telephone had been restored in 62 of 109 towns and villages in quake zone, enabling local residents to communicate in different ways. Here we can derive a 57% accessibility rate for traditional channels. We make a conservative assumption here that the accessibility rate of text based communication over the cellular network remains in the 74%-77% range of May 22.

5. June 9: On the June 9th update of the State Electricity Regulatory Commission, still 16% of affected towns and villages were without power. We make the assumption that once power is restored to an area, people are once again able to access both twitter, and traditional information channels on an equal basis. Since the high demand on the cellular network is no longer a factor, we will no longer apply the 0.8 discount factor. We simply have an 84% accessibility rate for both communication channels. Cellular communication accessibility could, and likely was higher, but again keeping our estimates conservative, we will assume the 84%.

The detailed comparison of accessibility between the twitter upper and lower bounds and mainstream information channels is shown in Figure 4.

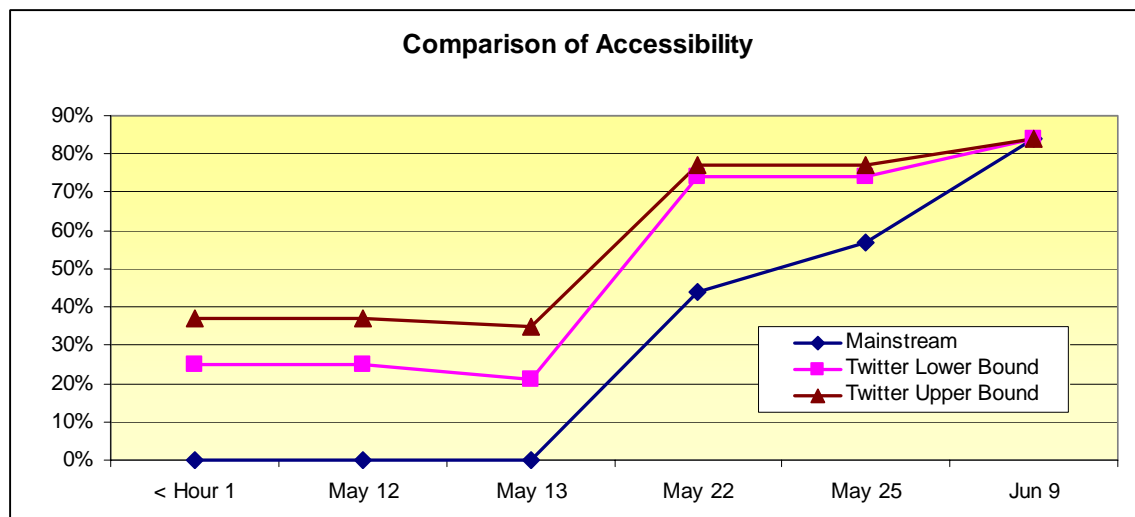


Figure 4. Comparison of Accessibility

From this hypothetical figure, we can see in the emergency response system, twitter is the much more effective tool for information dissemination in the critical moments following the event and its accessibility never falls below that of mainstream media. Regardless of whether we look at the lower or upper bound of our conservative twitter accessibility estimates, they both show twitter to be significantly more accessible in the emergency situation over the entire time period. For emergency response, this is especially the case during the most essential timeframe, immediately after the event, but is also applicable in all following timeframes.

In analyzing the dimension 'timeliness', the focus of analysis is on the actual time information became available to the whole world. How quickly information becomes available has a direct effect on the speed of action by the emergency responders and volunteers. When looking at 'accessibility', our focus is on when that information became accessible to those affected in the earthquake area. This is extremely important in terms of emergency responders being able to find the victims, as well as in allowing the victims to better locate assistance, improve their conditions, and contact loved ones. In the next two sections, we are going to look at the information quality dimensions 'accuracy' and 'completeness'. As these two dimensions are not as easily quantified as the previous two, content analysis will be used as a proxy to comparatively measure the two information channels.

4.3 Accuracy

A semantic content analysis approach was used to quantify the following two dimensions of information quality: accuracy and completeness. Busch and et al. (2005) had an excellent guide to content analysis: Content analysis is a research tool used to determine the presence of certain words or concepts within texts or sets of texts. Researchers quantify and analyze the presence, meaning and relationship of such words and concepts, then make inferences about the messages within the texts, the writer(s), the audience, and even the culture and time of which these are a part (Busch and et al., 2005).

CATPAC is the software which we used for the following content analysis. CATPAC is a program that can read any text and summarize its main ideas (www.galileoco.com). This self-organizing artificial neural network computer program has been optimized to read and analyze large amounts of text (Kim et al., 2005). By reading the text, it can produce a lot of outputs, such as determining the most frequently used symbols and words, identifying the

patterns of similarity based on those words' co-occurrences, and providing other different cluster analysis.

In the research conducted by Singh et al. (2009), a list of keywords was created to represent different dimensions of information quality. In order not to underestimate the importance of a concept, they first chose a few synonyms (such as 'available', and 'reachable', and 'accessible'). Furthermore, in order to best cover the relevant words, both synonyms and antonyms (such as 'inaccessible' and 'accessible') were included for each quality dimension in their research. We have adopted their word lists in our research and also assign each word equal 'weight'.

Information Quality Dimension	Keywords
Accuracy	accurate, inaccurate, accurately, confirmed, uncertainty, uncertain, rely, reliable, relied, wrong, false

Table 2. Keyword List for Accuracy Dimension Adopted from Singh et al. (2009)

We have included the words in the keyword list in the 'include' file of the CATPAC program to make sure that all the keywords appear in the program's dendrogram output. Thus we can easily sum up the frequency of each word in the list. Then we calculated the 'hit density' of sum of the frequency of the keywords within both traditional media and twitter. This allows us a method of measurement with which to compare to two mediums. Efthimiadis (1993) defined hit density as the ratio of the number of 'hits' divided by the number of content-bearing words in an article. Our calculation of hit density is a simple ratio of the number of sum of the frequency of the key words, as identified by CATPAC, to the total number of words appearing in the articles and tweets. We have grouped the articles and tweets by the following five time frames and summarized the content and hit density for each. As Singh et al. (2009) suggested, we also reviewed all the high frequency words in the output to make sure that we did not miss any other high frequency keyword that can possibly represent the information quality dimension. The summaries of hit density of the 'accuracy' dimension for both mainstream papers and twitters are shown below.

Accuracy: Mainstream Articles	Total number of words	Sum of the appearances of the keywords	Hit Density
< Hour 1	338	1	0.002959
Btw Hour 2 to End of Day 1	28851	63	0.002184
Btw Day 2 to End of Week 1	26020	159	0.006111
The Second Week	20037	110	0.005490
Btw Week 3 to End of 1 month	17069	83	0.004863
Sum	92315	416	0.004506

Table 3. Hit density of the 'accuracy' dimension for mainstream articles

Accuracy: Twitter	Total number of words	Sum of the appearances of the keywords	Hit Density
< Hour 1	2913	4	0.001373
Btw Hour 2 to End of Day 1	7592	2	0.000263
Btw Day 2 to End of Week 1	2438	1	0.000410
The Second Week	891	2	0.002245
Btw Week 3 to End of 1 month	1478	3	0.002030
Sum	15312	12	0.000784

Table 4. Hit density of the 'accuracy' dimension for tweets

The detailed comparison of accuracy between the mainstream information channels and twitter is shown in figure 5. We multiplied the scale of the ‘hit density’ axis by 10^3 in the figures for ease of viewing.

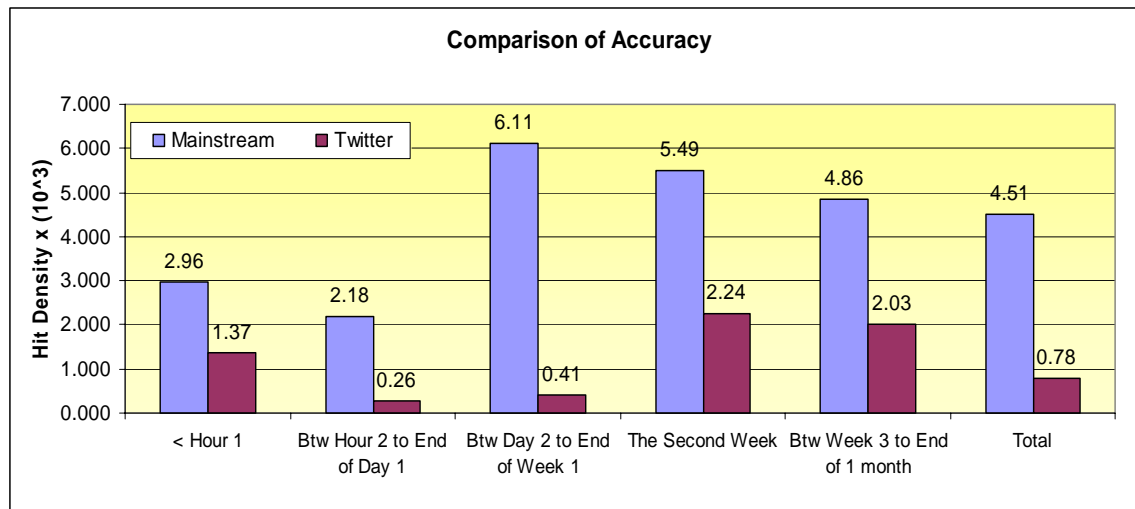


Figure 5. Comparison of Accuracy

As viewed via this method of ‘hit density’, traditional media is at all times shown to be more effective in communication accuracy. We define the ratio between mainstream and twitter as the mainstream hit density divided by the tweet hit density. It is a low of 2.2 (2.96 divided by 1.37) during the first hour, and a high of 14.9 between day two and the end of the first week. Overall, traditional media has a hit rate 5.8 times that of twitter with regards to accuracy. While still trailing traditional media, twitter does in fact show a higher focus during the first hour on accuracy than it does during the rest of the first week. It is also during this first hour where twitter is closest to traditional media using this measurement of accuracy. While the significance is unclear, it is also interesting to note that traditional media sees a large spike in accuracy starting on day two, which then slowly declines, while twitter shows similar behavior, but does not see the increase until the second week. The accuracy ratio between mainstream and twitter across different time frames is shown below.

Accuracy Ratio: ‘Mainstream’ Hit Density : ‘Twitter’ Hit Density	
	Ratio
< Hour 1	2.2
Btw Hour 2 to End of Day 1	8.3
Btw Day 2 to End of Week 1	14.9
The Second Week	2.4
Btw Week 3 to End of 1 month	2.4
Total	5.8

Table 5. Accuracy ratio between mainstream and twitter

One reason for the higher hit density for mainstream media coverage is twitter’s 140 character limit. Combined with the fact then when filtering for the words China, earthquake, and the space take up 16 of these characters, this leaves a mere 124 characters for the key words to appear in. Furthermore, Twitter’s built-in character limit encourages the use of abbreviations and more concise words. A twelve-character word such as ‘insufficient’ is less likely to be used in a twitter message as it consumes such a large percentage of the character limit. Traditional media obviously does not have this constraint.

Another cause for the gap between the hit density of the mainstream and twitter mediums is the large amount of additional noise found in twitter. While the mainstream

media is very focused on reporting what has happened, twitter also contains a much higher weight of messages which are merely comments and anecdotes from people. One must filter through many more messages in twitter in order to uncover the information bearing ones. This has largely been done for us in advance by the traditional media.

The Twitter medium is more focused on what is happening immediately around people. There is a misalignment between this focus, and that of the mainstream media. This is particularly evident with the increase in the hit density ratio between mainstream media and twitter in the second day, and the remainder of the first week. While the newspapers and television were busily reporting how big the earthquake was, where it struck, and ensuring this information was accurate for days after it occurred, people on twitter had moved on and were communicating on the big picture of what was happening around them currently. There is a very quick shift in focus from the earthquake to the earthquake's effect. As more time passes, the two mediums interests re-align as the mainstream media's relative focus again more closely mirrors that of the twitter community. We can see the hit density ratio then reverts back to what it was during the first hour.

From the perspective of accuracy, traditional media channels still must play an important roll in emergency response systems. Twitter can be most effectively used in order to gather as much information as quickly as possible in the immediate moments after the disaster event, but traditional media channels need to be used during the entirety of the timeline in order to confirm this information's accuracy. It is very important that the designers of emergency response systems are aware of it.

4.4 Completeness

We used the same methodology as discussed in the 'accuracy' dimension for the content analysis of the 'completeness' dimension. The keywords are listed in Table 6.

Information Quality Dimension	Keywords
Completeness	adequate, complete, entire, entirely, inadequate, incomplete, insufficient, integrity, unaware, unknown, wholeness,

Table 6. Keyword List for Completeness Dimension Adopted from Singh et al. (2009)

The summaries of the hit density of the 'completeness' dimension for both mainstream papers and twitters are shown below:

Completeness: Mainstream Papers	Total number of words	Sum of the appearances of the keywords	Hit Density
< Hour 1	338	0	0.000000
Btw Hour 2 to End of Day 1	28851	21	0.000728
Btw Day 2 to End of Week 1	26020	72	0.002767
The Second Week	20037	77	0.003843
Btw Week 3 to End of 1 month	17069	57	0.003339
Total	92315	227	0.002470

Table 7. Hit Density of the Completeness Dimension for Mainstream Papers

Completeness: Twitter	Total number of words	Sum of the appearances of the keywords	Hit Density
< Hour 1	2913	2	0.000687
Btw Hour 2 to End of Day 1	7592	1	0.000132
Btw Day 2 to End of Week 1	2438	2	0.000820
The Second Week	891	1	0.001122
Btw Week 3 to End of 1 month	1478	1	0.000677
Total	15312	7	0.000457

Table 8. Hit Density of the Completeness Dimension for Tweets

The detailed comparison of completeness between the mainstream information channels and twitter is shown in Figure 6. We multiplied the scale of the 'hit density' axis by 10^3 in the figures for ease of viewing.

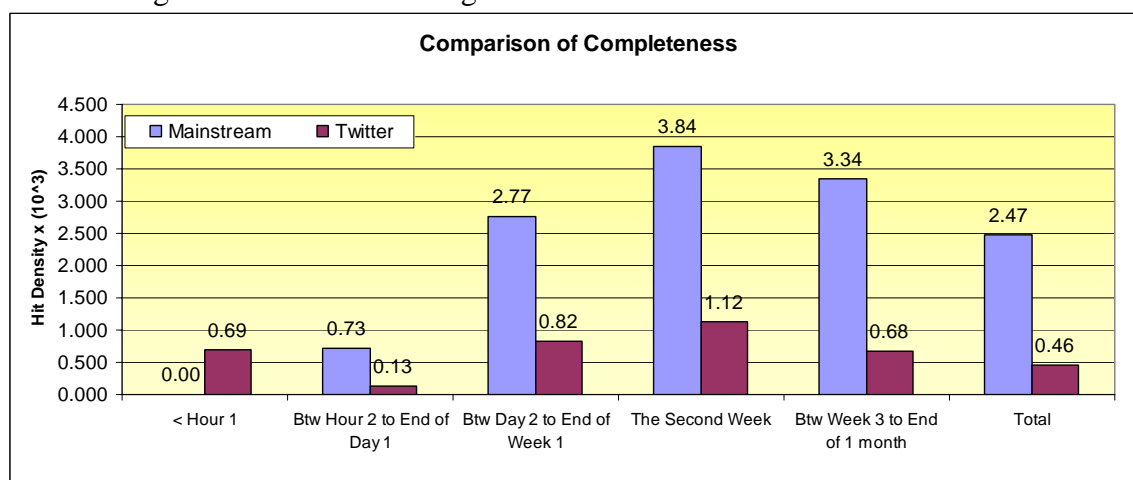


Figure 6. Comparison of Completeness

A comparison of completeness shows that in the first hour, twitter has one of its higher hit rates of the entire time period, while traditional media contained not a single word exhibiting completeness. It scored zero. After hour two, traditional media once again indicates a higher level of completeness than twitter, with both exhibiting a pattern of increasing to a peak during the second week, and dropping slightly beyond that. The overall hit rate for completeness was 5.4 times greater in the traditional media than twitter. After the first hour, results were much smoother than when we looked at accuracy, with ratios staying within a range of 3.4 to 5.5. The completeness ratio between mainstream and twitter across different time frames is shown below.

Completeness Ratio: 'Mainstream' Hit Density : 'Twitter' Hit Density	Ratio
< Hour 1	0.0
Btw Hour 2 to End of Day 1	5.5
Btw Day 2 to End of Week 1	3.4
The Second Week	3.4
Btw Week 3 to End of 1 month	4.9
Total	5.4

Table 9. Completeness Ratio between Mainstream and Twitter

In looking at completeness, we again have the same instance as we did with accuracy with regards to twitter's 140 character limit, and additional noise contributing to the gap between the hit density of mainstream media and twitter. One thing is very different however. After the first hour, the mainstream media and twitter quickly align with each other in their respective focus on completeness. The hit density ratio remaining within the relatively a narrow range, combined with the lower overall ratio between the hit densities show twitter to be more comparable to the mainstream reporting channel in completeness than accuracy, and infinitely better during the very first hour.

Similarly to as we discussed with regards to the accuracy dimension, with the exception of the moments immediately following the disaster event, emergency response systems still need to rely on mainstream information channels to ensure completeness of information. In the design of emergency response system, we should never overlook that those traditional information channels still serve as a sort of referee to the information coming out of the twitter channel.

4.5 Collective Intelligence¹

While we studied the 'accuracy' and 'completeness' dimensions of information quality, one of the functions that CATPAC program provides is a summary of all the high frequency words appearing in articles. There are 9 mainstream articles and 433 tweets in the first hour after the earthquake. Since we are primarily interested in the distribution of disaster news, we will focus on this time frame to compare the effectiveness of the collective intelligence provided by both information channels.

First we started with the top 10 frequency words in each of the 9 mainstream articles. Then we went through the tweets following their time stamps, and tried to identify how many tweets were needed to cover those same 10 high frequency words. The average number was 39. So on average, in order to cover the top 10 frequency words appearing in one article, 39 tweets are needed. The detailed data is shown in the table 10.

No	Number of words in the article	# of Tweets to cover the top 10 high frequency words in the article
1	276	21
2	643	42
3	325	47
4	576	32
5	298	37
6	407	51
7	587	30
8	412	34
9	542	61

Table 10. Competitive Intelligence

The average number of words those 9 articles contain is 452, while the average number of the words that each of the 433 tweets from the first hour contained is 11. Thus the average word number of one article is 41 times that of the corresponding tweets. Interestingly, only thirty-nine tweets were needed to cover all of the ten most frequently occurring words from one article. Put another way, a mainstream article of a length the equivalent of forty-one tweets has the same information content of only thirty-nine tweets. From this perspective, twitter is slightly more effective and efficient than the mainstream media in terms of collective intelligence. This number is a larger if one excludes the key search phrase 'China

¹ We thank an anonymous referee for the insight for this section.

Earthquake' from the word counts as it is highly unlikely to appear but a few times in an article, making up just 1-2 % of the content. Meanwhile by the nature of how the data was collected from twitter, the key phrase alone is 18% (2 divided by 11) of the content for micro-blogging. In this case, twitter will be even more effective in terms of collective intelligence immediately after the earthquake.

The Twitter medium is very focused on what is happening immediately around people. As discussed previously, the inherent characteristics of micro-blogging allow it to provide information, and simultaneously confirm it through the power of collective intelligence. Erroneous reports will be overwhelmed by the repeated reports of the correct information from other sources.

5. DISCUSSION AND CONCLUSION

This paper has been an exploration of Twitter as a rapid response news service as compared to mainstream newspaper media in the context of the China Earthquake of 2008. The China earthquake was the first large scale natural disaster where Twitter was used in a major way. As Homeland security consultant W. David Stephenson demonstrated how to use Twitter in emergencies in the episode of his video series '21st century disaster tips you won't hear from officials', he commented that twitter is not only one of the best tools for citizen reporting in emergencies, its real usefulness is its ability to get messages to users' friends and family and provide evacuation updates. The messages can include information about where the shelters are, distribution sites, and other contact information (Singel R. Oct 24, 2007). Observing twitter's growth, it is worth understanding what role twitter can play in distributing information during emergency response, and what its advantages and disadvantages are as it continues to gain a wider audience. In our analysis, we focus on the five important information quality dimensions: timeliness, accessibility, accuracy, and completeness, as well as collective intelligence, we have found that micro-blogging is a very effective tool for information dissemination in the critical moments following the disaster. This communication method, which requires extremely low bandwidth, may be the only accessible tool in a fragile communications network after a disaster. Furthermore, it enables not just a two-way communication; micro-blogging's unique structure also allows users to directly broadcast information amongst groups of people, and be seen and referenced by others. This broadcast ability is extremely critical in emergency response. While micro-blogging can contain a good deal of noise and extraneous information, it can be negotiated through in order to find the content with information value.

From our research, we have found that micro-blogging can serve as an excellent supplement to the traditional information channels, and if the circumstances required in a situation where it is the only effective communication tool available, micro-blogging could certainly serve as a replacement in the short period of time after the disaster happens. Based on the well-defined dimensions of information quality, we tried to provide a complete picture of micro-blogging in distributing information in emergency response. We aim to raise the audience's interest in considering further development in utilizing micro-blogging as a new, flexible, and powerful information channel in emergency response. As Mills et al. (2009) stated, twitter has the potential to become a centrally-operated tool for crisis management organization (CMOs), municipal, state, and federal government agencies and other organizations involved in disaster response and recovery. We hope to focus on other iterations of the web 2.0 information channel in our future research, including text messaging and mobile voice communications. We hope our research can shed some light in this direction.

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6. REFERENCES

- Agence France Presse (AFP) (May 12, 2008) China quake: transport, communications chaotic. <http://www.theage.com.au/news/world/china-quake-transport-communications-chaotic/2008/05/13/1210444377453.html>
- Agence France Presse (AFP) (May 14, 2008) 'Twitters' beat media in reporting China earthquake. <http://en.kioskea.net/actualites/twitters-beat-media-in-reporting-china-earthquake-10370-actualite.php3>
- Alexander, J. and Tate, M.A. (1999) *Web Wisdom: How to Evaluate and Create Information on the Web*, Mahwah, NJ: Erlbaum.
- Asia Digital Map (Mar 22 2010) 7 Things Sina Microblog (Weibo) has that Twitter doesn't <http://www.asiadigitalmap.com/2010/03/7-things-sina-microblog-weibo-has-that-twitter-doesn-t/>
- BBC News (May 12 2008) Twitter and the China Earthquake, http://www.bbc.co.uk/blogs/technology/2008/05/twitter_and_the_china_earthqua.htm
- BBC Monitoring Asia Pacific. (May 12 2008) Earthquake Paralyzes Phone Networks in Southwestern China, BBCAPP
- Busch, C., Maret, P. S. D., Flynn, T., Kellum, R., Le, S., Meyers, B., et al. (2005). *Writing Guides: Content Analysis*. Colorado State University Department of English. <http://writing.colostate.edu/guides/research/content/>
- Buzzle.com (Feb 23, 2010) 2010 China Microblog Overview <http://www.buzzle.com/articles/2010china-microblog-overview.html>
- China Mobile and China Unicom (May 16 2008) China Unicom Chairman: Telcom Indus revamp to come soon, <http://www.cellular-news.com/story/31210.php>
- China Mobile (May 14 2008) China Mobile Repairing Damaged Base Stations in the Disaster Areas, on 5/14/08 Sinocast 10:23:33
- Chinese Embassy (May 22 2008) China Earthquake Death Toll Rises to 51,151, <http://www.china-embassy.org/eng/xnyfgk/t457178.htm>
- CNN (Dec 27 2009) Micro-blogs in China: Tweeting through the 'Great Firewall', <http://www.cnn.com/2009/TECH/12/24/china.micro.blogging/index.html>
- Dedeke, A. (2000) A Conceptual Framework for Developing Quality Measures for Information Systems, *The Proceedings of the 5th International Conference on Information Quality*.
- Dedrick, J. and Kraemer, K.L. (2001) China IT Report, *Electronic Journal of Information Systems in Developing Countries*, **6**, 2, 1-10.
- Delone, W.H. and McLean, E.R. (1992) Information Systems Success: The Quest for the Dependent Variable, *Information Systems Research*, **3**, 1, 60-95
- Delone, W.H. and McLean, E.R. (2003) The Delone and McLean Model of Information Systems Success: A Ten-year Update, *Journal of Management Information Systems*, **19**, 4, 9-30.
- EERI special earthquake report (Oct 2008) http://www.eeri.org/site/images/eeri_newsletter/2008_pdf/Wenchuan_China_Recon_Rpt.pdf

- Efthimiadis, E. N. (1993). A User-Centered Evaluation of Ranking Algorithms for Interactive Query Expansion. *The Proceedings of the 26th Annual International ACM SIGIR Conference on Research and Development in Information Retrieval*, Pittsburgh, PA.
- Eppler, M. and Muenzenmayer, P. (2002) Measuring Information Quality in the Web Context: A Survey of State-of-the-Art Instruments and an Application Methodology, *The Proceedings of the 7th International Conference on Information Quality (ICQ-02)*
- Fong, M.W.L. (2009) Digital Divide between Urban and Rural Regions in China, *Electronic Journal of Information Systems in Developing Countries*, **36**, 6, 1-12
- Gregg, D.G. (2010) Designing for Collective Intelligence, *Communications of the ACM*, 53, 4, 134-138
- Helfert M., Foley O., Ge M. and Cappiello C. (2009) Limitations of Weighted Sum Measures for Information Quality, *Proceedings of the Americas Conference on Information Systems*.
- Huang K.T., Lee Y. W. and Wang R.Y. (1999) Quality Information and Knowledge Management, Prentice Hall.
- Kahn, K., Strong, D. and Wang, R. (2002) Information Quality Benchmarks: Product and Service Performance, *Communications of the ACM*, **45**, 4, 184-193
- Katerattanakul, P. and Siau, K. (1999) Measuring Information Quality of Web Sites: Development of an Instrument, *Proceedings of the 20th International Conference on Information Systems*, Charlotte, North Carolina, USA: 279-285
- Kim, D., Song, Y.I., Braynov, B.R. and Rao, H.R. (2005) A Multidimensional Trust Formation Model in B-to-C E-commerce: A Conceptual Framework and Content Analyses of Academia/Practitioner Perspectives, *Decision Support Systems*, **40**, 143-165
- Klein, B.D. (2002) When Do Users Detect Information Quality Problems on the World Wide Web? *Proceedings of the Americas Conference on Information Systems*.
- Lee, Y., Strong D., Kahn B. and Wang R.Y. (2002) AIMQ: A Methodology for Information Quality Assessment, *Information & Management*, **40**, 2, 133-146
- Leung, H.K.N. (2001) Quality Metrics for Intranet Applications, *Information & Management*, **38**, 3, 137-152
- Liu, Z.M. and Huang, X.B. (2005) Evaluating the Credibility of Scholarly Information on the Web: A Cross Cultural Study, *The International Information and Library Review*, **37**, 2, 99-106
- Luo, G. (2009) E-government, People and Social Change: A Case Study in China, *Electronic Journal of Information Systems in Developing Countries*, **38**, 3, 1-23
- Mills, A., Chen, R., Lee, J. and Rao, H.R. (2009) Web 2.0 Emergency Applications: How Useful can Twitter be for Emergency Response? *Journal of Information Privacy & Security*, **5**, 3, 3-26
- Naumann, F. and Rolker, C. (2000) Assessment Methods for the Information Quality Criteria, *Proceedings of the 5th International Conference on Information Quality*
- New York Times (Jun 2 2009) To shut off Tiananmen talk, China disrupts sites, http://www.nytimes.com/2009/06/03/world/asia/03china.html?_r=1
- Nielsen (Jun 2, 2009) Time spent on facebook up 700 percent, but MySpace.com still tops for video, according to Nielsen, http://en-us.nielsen.com/main/news/news_releases/2009/june/time_on_facebook
- Parker, M.B., Harpe, D.L. and Wills, G.B. (2006) An Evaluation of Information Quality Frameworks for the World Wide Web, *Proceedings of the 8th Annual Conference of WWW Applications*, Bloemfontein, Free State Province, South Africa

- Singh, P., Singh, P., Park, I., Lee, J.K. and Rao, H.R. (2009) Information Sharing: A Study of Information Attributes and their Relative Significance during Catastrophic Events, in: Knapp, K. (Ed.) *Cyber-Security and Global Information Assurance: Threat Analysis and Response Solutions*, IGI Publishers.
- O'Brien, C. (July 30, 2008). Is twitter the newsroom of the future?
<http://www.pbs.org/idealab/2008/07/is-twitter-the-newsroom-of-the-future005.html>
- People's Daily (May 15, 2008) Text message provides relief.
<http://english.people.com.cn/90001/6411128.html>
- PC World (Feb 22 2010) China's President Skips Twitter, opens state-tied microblog
http://www.pcworld.com/article/189919/chinas_president_skips_twitter_opens_stateti_ed_microblog.html
- People's Daily (May 22, 2008) Text messages raise 100 mln yuan for China's quake survivors. <http://english.peopledaily.com.cn/90001/90776/6416553.html>
- Pipino, L. Lee, Y.W. and Wang, R. Y. (2002) Data quality assessment, *Communications of the ACM*, **45**, 4, 211-218.
- ReadWriteWeb (Mar 5, 2010) China's Twitter Clones.
http://www.readwriteweb.com/archives/china_twitter_clones.php
- SearchEngineLand News (May 12 2008) Twitter beats Wow, by 3 minutes the USGS with China earthquake news, <http://searchengineland.com/twitter-beats-wow-by-3-minutes-the-usgs-with-china-earthquake-news-13976>
- Shanks, G. and Corbitt, B. (1999) Understanding Data Quality: Social and Cultural Aspects, *Proceedings of the 10th Australasian Conference on Information Systems*
- Singel R. (October 24, 2007) In Disasters, Everyone, not just Bloggers, Should Use Twitter, <http://www.wired.com/threatlevel/2007/10/in-disasters-ev/>
- Soriano, C.R.R. (2007) Exploring the ICT and Rural Poverty Reduction Link: Community Telecenters and Rural Livelihoods in Wu'an, China, *Electronic Journal of Information Systems in Developing Countries*, **32**, 1, 1-15
- State Electricity Regulatory Commission (SERC_1) <http://www.china-un.org/eng/hyyfy/t458807.htm>
- State Electricity Regulatory Commission (SERC_2)
<http://new.fmprc.gov.cn/ce/ceun/eng/zt/earthquake20080512/t463997.htm>
- Strong, D., Lee, Y. and Wang, R. (1997) Data Quality in Context, *Communications of the ACM*, **40**, 5, 103-110
- Swanson, E.B (1987) Information Channel Disposition and Use, *Decision Sciences*, **18**, 131-145
- Timesonline (Feb 23 2010) China's latest mystery: Hu Jintao and the vanishing micro-blog, http://technology.timesonline.co.uk/tol/news/tech_and_web/the_web/article7037218.ece
- Tweetip (May 12 2008) Tweetip – Earthquake China – Tweet count per 5 mins (est),
<http://tweetip.tumblr.com/search/sichuan+earthquake>
- USA Today (5/19/2009) China allows bloggers, others to spread quake news.
http://www.usatoday.com/tech/world/2008-05-19-china-bloggers-earthquake_N.htm
- USGS (May 2008) Magnitude 7.9 – Eastern Sichuan, China,
<http://earthquake.usgs.gov/eqcenter/eqinthenews/2008/us2008ryan/#summary>
- Vandenbosch B., and Higgins C. (1995) Executive Support Systems and Executive Preference: A Comparison of Information Channel Selection Theories, *Information Systems Journal*, **5**, 105-118
- Wall Street Journal News (May 22, 2008)
<http://blogs.wsj.com/chinarealtime/2008/05/22/getting-back-on-the-line-in-sichuan/>

- Wand, Y. and Wang, R.Y. (1996) Anchoring data quality dimensions in ontological foundations, *Communications of the ACM*, **39**, 11, 86-95
- Wang, R.Y. and Strong, D.M. (1996) Beyond Accuracy: What Data Quality Means to Data Consumers, *Journal of Management Information Systems*, **12**, 4, 5-34
- Weiss, A. (2005) The Power of Collective Intelligence, *Networker*, **9**, 3, 16-25
- Xinhua (2008) Magnitude of SW China Earthquake Revised to 8.0
http://english.gov.cn/2008-05/18/content_981724.htm
- Zeist, R.H.M. and Hendriks, P.R.H. (1996) Specifying Software Quality with the Extended ISO Model, *Software Quality Management IV – Improving Quality*, BCS: 145-160
- Zhu, X. and Gauch, S. (2000) Incorporating Quality Metrics in Centralized/distributed Information Retrieval on World Wide Web, *Proceedings of the 23rd International ACM SIGIR Conference on Research and Development in Information Retrieval*, Athens, Greece.