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ABSTRACT

Many proposed technological solutions to emergency response during disasters involve the use of cellular telephone technology. However, cell phone networks quickly become saturated during and/or immediately after a disaster and remain saturated for critical periods. In this study, we investigated cell phone use by Virginia Tech students, faculty and staff during the shootings on April 16, 2007 to identify patterns of communication with social network ties. We administered an online survey to a random sample from our pool to capture communications behavior with social ties during the day of these tragic events. The results show that cell phones were the most heavily used communication technology by a majority of respondents (both voice and text messaging). While text messaging makes more efficient use of bandwidth than voice, most communication on 4/16 was with parents, since the majority of the sample is students, who are less likely to use text messaging. Our findings should help in understanding how cell phone technologies may be utilized or modified for emergency situations in similar communities.

Keywords

Emergency communication, cell phone technology, survey research.

INTRODUCTION

April 16, 2007 was a Monday. The weekend before had been Admitted Students days on the VT campus. Seung-Hui Cho shot two students early Monday morning (about 7:15) in a dormitory, and the police had taken someone into custody within an hour. During this time, Cho had gone by the post office and dropped off a package to NBC news with a videotape of himself telling his story of the killings he was yet to carry out. About 9:30 he barricaded the doors of Norris Hall on campus, and went from classroom to classroom, shooting 29 students and faculty, before shooting himself. A total of 32 people, including Cho, died that morning.

Cell phone networks were overwhelmed during the tragic shootings at Virginia Tech on April 16, just as they were during Katrina and 9/11 (May, 2006; Weiser, 2006). Many notification forms during emergencies overburden not only landlines, but also wireless (or ubiquitous) communication among individuals. We know from various studies that the first responders in an emergency are often the immediate individuals on site who can provide information to authorities (May, 2006). Just as authorities do, citizens need to be able to communicate effectively and reliably under such circumstances. Therefore, it is important that we understand communication patterns and system usage in emergency situations.

Many studies of emergency communication usage have examined public sector communication systems, such as those used by police, fire, and rescue workers (Mehrotra, 2007; National Research Council, 2007; Schooley, Marich and Horan, 2007; Weiser, 2006). A few studies have focused more recently on a combination of public sector agencies and lay persons' use of communication networks, including citizen use of government websites, and fixed and mobile telephone services (Owen, 2005; Steinberg, 2006; Palen and Liu, 2007; Palen and Vieweg, 2008). We build on studies that focus on ordinary citizens' use of communication networks. Specifically, we examined fixed and wireless voice communications, text messaging, electronic mail notifications, and web-based information sources for Virginia Tech affiliates (students, faculty and staff) during the tragic events of

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April 16th. We focused our study primarily on cell phone use.

Mobile communication (particularly, cell phone usage) by citizens is of special interest given that it is the communication channel that ordinary people are most likely to have close at hand in the moment of an emergency (Horrigan 2007). Moreover, in future crises, the cell phone is likely to be used increasingly for high bandwidth services, as some people caught in an emergency will also attempt to receive information over their mobile devices from the Internet and other networked sources (e.g., to obtain web-based news over their cell phone).

For these interrelated reasons, we think that the use of text messaging is an important component as we plan ahead for crisis management. Text messaging could play a vital role in emergency response for several reasons: 1) it is very low bandwidth; 2) it is asynchronous; and 3) it is currently underutilized by subscribers in the United States, because providers typically charge extra for text messaging services. In situations where the citizenry forms a vital cadre of "first informers" (which is increasingly more common owing to the ubiquitous presence of mobile communication devices), text messaging can be the most efficient form of communication over a given network. Moreover, cell phone penetration has reached deep into the socio-economically disadvantaged segments of the US population (Horrigan, 2007). Hence, cell phones (along with the digital services that come with them) represent a compelling medium for broad access to digital information and communication.

PRIOR RESEARCH

Emergency (or crisis) communication management pertains to the use of communication channels and messages to coordinate activity and convey information among citizens, rescue workers, government agencies and others. Our study seeks to build on an area of work known as emergency information management and, more specifically, on a growing research area referred to as 'crisis informatics' -- a term coined by Hagar (2007) and extended by Hughes et al. (2008) and Palen et al. (2009), among others. Speaking on the role of information and communication technology (ICT), Palen and colleagues note that 'crisis informatics' includes "empirical study as well as socially and behaviorally conscious ICT development and deployment. Both research and development of ICT for crisis situations need to work from a united perspective of the information, disaster, and technical sciences." It is the sharing of information in a disaster that is especially crucial, and different types of ICT facilitate sharing to a greater or lesser degree based on a variety of circumstances. The recent literature on crisis communication includes analyses of information seeking behavior following such disasters as September 11, 2001 (Schneider and Foot, 2004), Hurricane Katrina (James and Rashed, 2006), the southern California wildfires in 2007 (Sutton et al., 2008; Schlovski et al., 2008), and the Virginia Tech shooting tragedy April 16, 2007 (Palen et al., 2009; Vieweg et al., 2008; and Sheetz et al., 2009).

The Hurricane Katrina disaster that began August 29, 2005 produced several lessons regarding communication and information exchange (May, 2006). Among these are: 1) the importance of citizens to provide information (and misinformation) to each other and to rescue workers and related authorities; 2) there cannot be over-reliance on a single communication infrastructure, such as wireless or terrestrial communications; and 3) individuals possess unprecedented capacity to access, share, create and apply information (May, 2006; Peskin and Nachison, 2005). During Katrina, the public sector communication used by police, fire and rescue workers, often failed due to incompatibility among systems and across geographical districts (Le et al., 2006). In response, researchers at Virginia Tech and their affiliated collaborators have been developing 'smart radio' communication systems that automatically determine the frequency and other necessary specifications in order to interconnect with diverse networks. "Smart radio" (cognitive, adaptive, and software defined radio) offers the promise of greatly alleviating spectrum scarcity and increasing the diversity of users and applications. Radios that can locate unused spectrum should significantly reduce congestion, and encourage competitive, commercial and community entry. Such technologies will have significant impacts on existing stakeholders, on market structures and on network performance when they become available.

In previous studies of the events of April 16 at VT, Palen and colleagues (2009) examined the use of the Internet, including social network sites, for communication during the crisis. For example, they studied the Facebook group named "I'm OK at VT" and found that students joined the group not only to make their own safety known, but also to assist in searches for other students (Vieweg et al., 2008). In their study of ordinary people coordinating disaster relief on the Internet, Torrey and colleagues (2007) found that people quickly organized themselves into small blog communities or ongoing discussion forums. They found that a large number of dispersed individuals were able to collaborate on time-critical tasks. White et al., (2009) also found effective use of online social networks for communication and information exchange in response to crisis.

These works have reported that much citizen enabled communications that take place during disaster take place online. Our work focuses on cell phone use specifically, and finds that most of the communications that took place on 4/16 by students was via mobile phones.

METHODOLOGY AND PLAN OF WORK

We used mixed methods to solicit and preserve data, including one-on-one interviews, online surveys, and emails through the university system. We designed and then administered an online survey from November 2007 through January 2008 requesting participation by emails through the university system. We conducted follow up interviews with a subset of survey respondents in February and March 2008.

We contracted with the VT Center for Survey Research to provide us with ID numbers blind coded to e-mail addresses (to preserve confidentiality as approved by the VT IRB) of a random sample of students, faculty and staff from the total VT population (about 36,000). We sought a sample that was proportional to the campus population; that is, in 2007, there were about 29,000 full-time students (undergraduate and graduate students) or about 80% of the total VT population; there were about 3200 full and part-time faculty (9%), and about 3900 full and part time staff who made up about 11% total of the total VT population.

We contacted 4000 students, 350 faculty and 350 staff by email and invited them to participate in our study of cell phone use on 4/16. We used the Dillman method (1978, 1999) in administering the online survey. Specifically, we sent an initial email to the randomly selected sample alerting them to the study, and letting them know that we would be sending a link in the next email to the online survey. A few days later, we sent another email to them with a link to the survey. We sent two follow up reminders about two weeks and four weeks later, with the link to the survey, but only to those individuals in the sample who had not already completed it. In the first email alerting them to the study, we asked potential respondents (faculty, staff and students) not to throw away their non-university phone bills for April – the purpose is to 'freeze' the information as soon as possible to facilitate collection. The sample did not include the entire freshman class since they would not have been on campus the prior Spring semester when the tragedy occurred; and Spring semester seniors, since they would have graduated and left campus to destinations unknown to us.

Random Sample Survey and Interview Questions

The online survey and follow up interviews asked about general communication on that day (e.g., land line phones, cell phones, email, and Internet). While we did not ask specifically about Twitter use, we had an open category for 'other' under forms of communication used that day. No one wrote in Twitter. We asked detailed questions about cell phone use, such as, how and when the respondent communicated, with whom (type of relationship, not specific individual by name), duration of the communication, whether the communication was incoming or outgoing, and the location of their contact (i.e., local or non-local). The categories we used for "type of relationship" were: parent, spouse or romantic partner, child, other family member, close friend, friend, acquaintance, and other. Thus, our data are about the 'kinds of relationship' with whom the subject communicated (and not the specific identity of the communicant).

We followed a standard social network analysis of individuals' relationships with others with whom they communicated on that day: specifically, strong and weak tie relationships. The strength of a tie is a combination of the amount of time, emotional intensity, intimacy (mutual confiding) and reciprocal services that characterize the tie (Berkowitz, 1982; Fischer et al, 1977; Granovetter, 1973; Marsden and Lin, 1982). Strong ties are characterized by (Wellman, 1992, pp. 211-212): 1) a sense of the relationship being intimate and special, with a voluntary investment in the tie and a desire for companionship with the tie partner; 2) an interest in being together as much as possible through frequent interactions in multiple social contexts over a long period (perhaps this definition excludes the teenager to parent relationship, as many students may not want this at this point in their lives – although generally child-parent is a strong tie); and 3) a sense of mutuality in the relationship, with the partner's needs known and supported. Conversely, weak ties are more instrumental than strong ties – providing informational resources rather than support and exchange of confidences. In an emergency situation, individuals are likely to contact their strong ties to assure them that they are okay or that they need help; they are likely to contact weak ties, such as, fellow members of groups with which they are affiliated after the emergency has subsided in order to bolster needed help, emotional support or companionship.

There were two main parts to the online survey. Part A consisted of yes/no, multiple choice and Likert scale types of questions about the respondent's communication behavior on April 16, 2007, including use of other communication media, such as television, desktop internet access, radio and face-to-face interactions. We also asked in Part A for standard demographic and VT status information (e.g., gender, age, and whether the

respondent was a student, faculty or staff person). Part B consisted of questions presented in a table format about each specific cell phone communication/calls of the respondent during the day of April 16. The items collected for each communication included kind of relationship with the contact, whether the communication was voice, text or Internet access, and by time of day.

The Part B section of the survey also included questions for each communication about the duration of the communication and the location of the social contact (for example, within 100 miles, farther than 100 miles, as measures of local and non-local contacts). The respondents provided these data for each individual communication, starting with the first use (if any) of their cell phone that day. For example, the first use was typically a phone call to "spouse/significant other" or a parent. So, all the information about that call was included in the table. Given that the shooting occurred in April 2007 and we conducted the survey between November 2007 and January 2008, we encouraged respondents to use their actual cell phone bill when completing Part B in order to recall more accurately their cell phone use that day. To facilitate this we included links to the billing websites of cell phone providers.

At the end of the online survey, we asked respondents whether they would be willing to be contacted for a follow-up interview. For the interviews, we created a stratified sample of 31 individuals from the pool of 470, including faculty, students and staff, again roughly proportional to the campus population. Specifically, we interviewed 21 students (undergraduate and graduate), 5 faculty and 5 staff. To elaborate on the surveys, in the interviews we solicited more of the rationale and other motivating factors about their cell phone use on April 16. In addition, the interview protocols allowed respondents to describe where they were at the time of the shootings and throughout the day. The main results of the interview portion of the study are reported in Sheetz, et al. 2009.

RESULTS

We summarize the findings in several sections, including demographics, technology use, social networking factors and network performance problems. Many of the findings are consistent with other studies and are not surprising. However, our interest is in how these different modes of communication and types of relationships interact in an emergency situation. We expected and found that people communicated with their strongest social ties earliest, most often, and for longer duration than weaker ties. These are some of the defining characteristics of strong ties, i.e., someone with whom a person communicates more frequently. We were also interested in cell phone use for text messaging and the implications for its use in crisis situations.

Demographics

From our pool of all VT faculty, undergraduate and graduate students (except for freshmen and seniors who would not have been enrolled in 2008 when we conducted the surveys and interviews), the VT Center for Survey Research created a random sample of 4000 students, 350 faculty and 350 staff, as noted above. The number of respondents and response rates for each Part of the survey by different types of VT affiliates are shown in Table 1.

VT Status	Sample	Number of Respondents (N)		Response Rate	
		Part A	Part B	Part A	Part B
Student	4000	776	332	19%	8%
Faculty	350	95	41	27%	12%
Staff	350	108	48	31%	14%
Total	4700	979	421	21%	9%

Table 1. Survey Respondents and Response Rates

More people completed Part A only than completed both Parts A and B of the survey. (Respondents could not submit Part B if they had not already completed Part A.) The total number of respondents for Part A was 979 (that is, an overall response rate of 21%); the total number of respondents who completed both Parts A and B was 496 (an overall response rate of 9%). A higher response rate offers more reliable data analyses, although a 10% response rate for surveys is fairly typical. For Part A, the response rate ranged from 19% (students) to 31% (staff), with an overall response rate of 21%. For Part B, the response rates were lower, ranging from 8% (students) to 14% (staff), and an average of 9%. In Part A, as noted, respondents replied to questions in a multiple choice response format. In Part B, respondents provided detailed information on calls they made or received that day. The respondents were equally divided on gender, and, of course, the majority of respondents were college age students. Specifically, the bulk of students were undergraduates, with 369 students aged 19-20

and 206 aged 21-22.

Modes of Communication used on 4/16

Regarding various modes of communication used on 4/16, over 70% of all groups (students, faculty and staff) used both cell phone for voice calls and email from personal computers (Figure 1). Students were the greatest users of text messaging from cell phones and instant messaging (IM) from computers. Faculty and staff had greater access to land lines, since many of them were at offices. The vast majority (85%) of respondents indicated that having a cell phone on 4/16 was important; 64% reported it was extremely important.

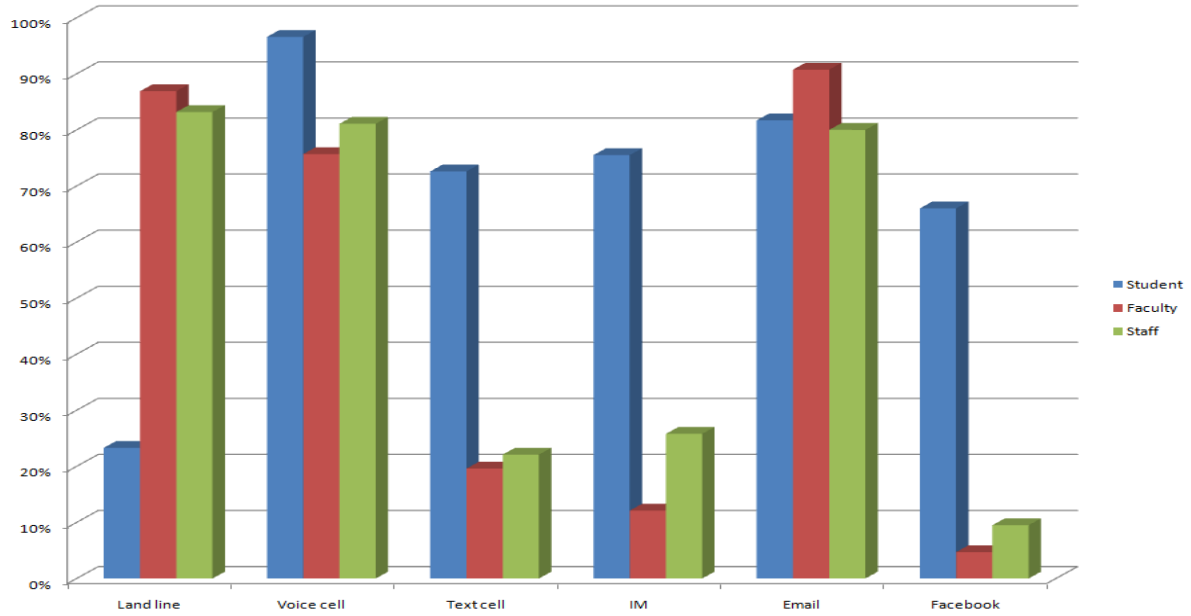


Figure 1. Modes of communication by type of user

Students also used Facebook for communication far more often than faculty or staff (Sheetz et al, 2009).

Cell Phone Use

Of all the different types of communication they used via cell phones (voice, text, internet, and email), the vast majority (82%) was voice; only 11% was text messaging (Figure 2). A very small percentage of all cell phone communication by all respondents was either email (N=63 or 2% of all cell phone communication) or internet (N=58 or 1% of all cell phone communication).

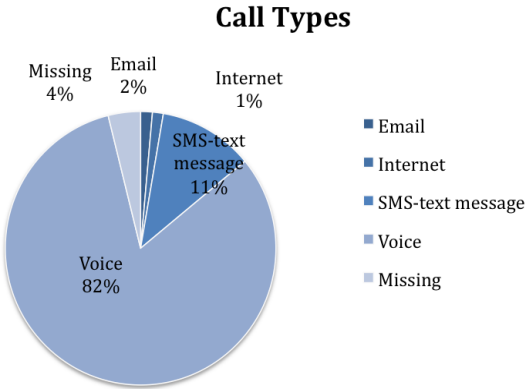


Figure 2. Type of Cell Phone Communication

Respondents listed a total of 4,481 cell phone communication entries (Part B of the survey) for that day. For each entry, they also listed what type of social tie the communication was with, such as, parent, sibling, close friend, acquaintance, etc., and other information noted earlier. Just over half of respondents contacted 10 or

fewer people by cell phone. The average number of cell phone communications of all types by all respondents was only 6, although some respondents had over 100 cell phone communication entries.

Social Network Ties and Cell Phone Use

We examined strong versus weak social ties by type of user and cell phone communication type (voice, text, email, internet). We coded strong social ties as those with family (i.e., parents, children, siblings, spouse or romantic partner, other family members) and close friends. Half of all people with whom respondents communicated by cell phone were family; another 25% were close friends, thereby together representing 75% of all social ties reached that day by cell phone (Table 2).

Strength of Tie		Frequency	Percent
Strongest ties	Parent	1044	23.3
	Child	68	1.5
	Sibling	357	8.0
	Spouse/ Partner	410	9.1
	Other Family Member	373	8.3
	Close Friend	1101	24.6
	Friend	778	17.4
	Acquaintance	153	3.4
	Other	142	3.2
Missing		55	1.2
Total		4481	100%

Table 2. Call Frequency by Strength of Social Tie

Overall, respondents preferred to use cell phone voice communication with all relationship types except acquaintances (the weakest type of social network tie). Respondents' use of social networking sites was higher for acquaintances and friends than for stronger social relationships (see also Sheetz et al., 2009).

First calls and call duration

As the majority of respondents were students, and just over half (51%) of first calls were to a parent(s); the next biggest percentage of first calls were to a spouse or romantic partner (15%). There was a significant negative correlation between the strength of the tie and time from the shootings around 10 am (that is, as time passed, respondents communicated with weaker ties).

The overall pattern in the sequence of communication by cell phone with respondents' social ties showed the following progression: first communication was with parents, then spouse or romantic partner, then close friends, then friends, and then siblings. Siblings may come this far down along the progression because parents contacted the siblings of the respondents. This was revealed in the interviews. Some interviewees reported extensive calling trees, such that, the person the interviewee contacted reached many other people in their social network (i.e., siblings, other family members and friends).

The average duration of voice communication by cell phone was the same over time (about 3 and a half minutes). Nonetheless, a one-way ANOVA indicated significant differences in call duration across the level of social tie ($F=29.162$, $df=8/4037$, $p<.001$). People talked longer to a close family member, such as a parent ($M=3.15$, $SD=1.29$) than to close friends ($M=2.63$, $SD=1.28$) and talked with close friends longer than with friends ($M=2.40$, $SD=1.15$).

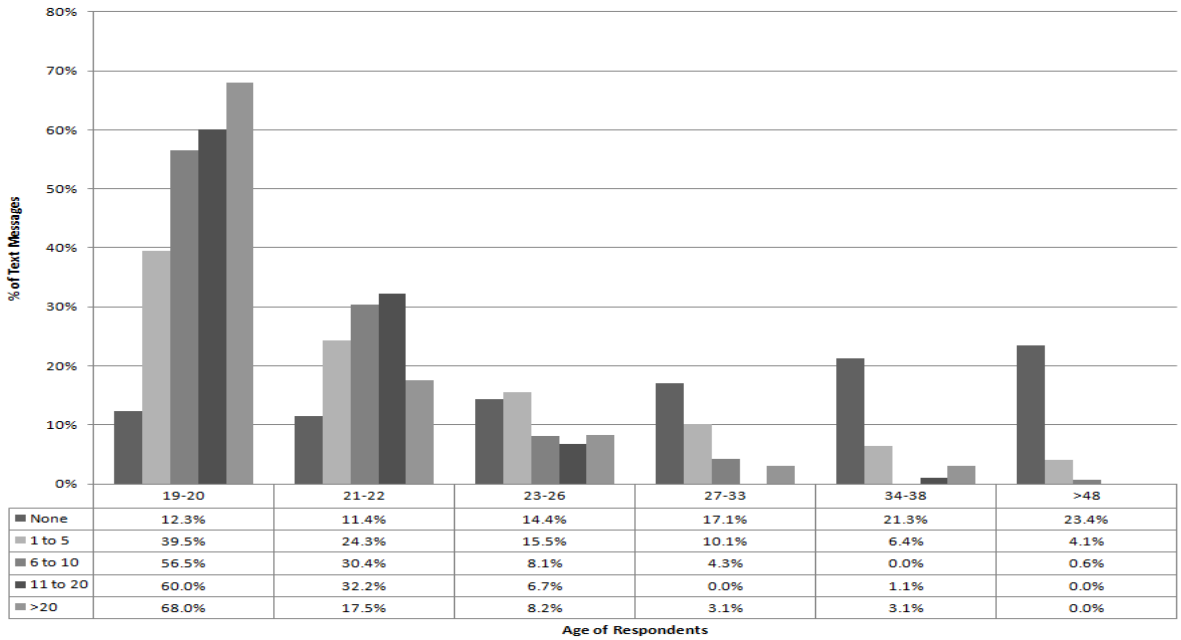
Text messaging

Of all the cell phone communications reported for 4/16 (4,481 total entries by all respondents), 11% was text messaging, as noted earlier. Students did most of the text messaging (Table 3). Not surprisingly, age and text messaging were significantly correlated. The number of text messages respondents reported sending on an average day was also significantly associated with age ($r=-.77$, $p<.00$); the negative correlation indicates that older users sent fewer text messages on an average day.

	Frequency (number of texts)	Percent
VT Students	469	92.5 %
VT Faculty	11	2.2
VT Staff	11	2.2
Other	16	3.1
Total	507	100 %

Table 3. Who Used Text Messaging on 4/16?

On 4/16, undergraduate students used text messaging more than graduate students, faculty, or staff. Figure 3 shows the number of text messages sent from cell phones by different age groups. The youngest respondents are clearly the most prolific texters. We grouped ages as they relate to status as lower and upper level undergraduate (19-20 and 21-22), younger and older graduate student (23-26 and 27-33) and middle age faculty and staff (34-38) and over 38. The specific status is not as important as age in relation to experience with text messaging.



	19-20	21-22	23-26	27-33	34-38	>48
None	12.3%	11.4%	14.4%	17.1%	21.3%	23.4%
1 to 5	39.5%	24.3%	15.5%	10.1%	6.4%	4.1%
6 to 10	56.5%	30.4%	8.1%	4.3%	0.0%	0.6%
11 to 20	60.0%	32.2%	6.7%	0.0%	1.1%	0.0%
>20	68.0%	17.5%	8.2%	3.1%	3.1%	0.0%

Figure 3. Text Messaging by Age

More females sent text messages on 4/16 than males. Texters reported they were more extroverted than non-texters and contacted almost 3 times as many people as non-texters. Students not only sent more text messages, they sent them primarily to other young people in their social networks (i.e., friends, close friends and siblings).

A cross-tabulation of the strength of social tie (e.g., parent, friend, acquaintance, etc.) by cell phone communication type (e.g., voice, text) showed significant differences. Students used text messaging primarily with strong ties within their age cohort (Table 4), such as their romantic partner or spouse, close friends and friends, and siblings.

With Whom	Text Messaging by:							Total	
	Students		Faculty		Staff		M		
Acquaintance	28	6%	0	0%	0	0%	2	30	6%
Child	0	0%	3	27%	0	0%	0	3	1%
Sibling	54	12%	0	0%	1	9%	1	56	11%
Close Friend	170	36%	0	0%	7	64%	6	183	36%
Friend	143	30%	4	36%	3	27%	6	156	31%
Other Family	23	5%	0	0%	0	0%	0	23	5%
Parent	13	3%	0	0%	0	0%	0	13	3%

Spouse/Partner	35	7%	4	36%	0	0%	1	40	8%
Other	3	1%	0	0%	0	0%	0	3	1%
Total	469	100%	11	100%	11	100%	16	507	100%

Table 4. Text Messaging with Social Ties

A graph of the number of text messages by time from the shootings mirrors that of voice, meaning that text suffered from network saturation also.

Satisfaction with Network Service

While 88% of respondents reported they were satisfied with their service on an average day, only 51% were satisfied on 4/16. Texters were more satisfied with their network service on an average day than non-texters, yet were less satisfied on 4/16 than non-texters. We conducted multiple regression tests to examine the primary determinants of satisfaction with cell phone performance on 4/16 (Table 5).

Cell Phone Satisfaction	Standardized coefficients (Beta)	Sig.
How many people were not able to get through	-0.416	0.000
How satisfied with cell phone service on average day	0.246	0.000
Connection problems	-0.171	0.000
How many calls were dropped	-0.142	0.000
How many different people contacted by cell phone	0.101	0.002

Table 5. Satisfaction with Cell Phone Network Service on 4/16

The model explains 38%, $p < .001$, of the variance of satisfaction. The variable with the most influence (reducing satisfaction) was 'the number of people that tried to call the respondent, but could not get through' (higher numbers corresponded with decreased satisfaction), followed by 'how satisfied with their cell phone service the respondent was on an average day', then connection problems.

Almost three-fourths of respondents reported they experienced problems over an extended period with their cell phone network performance on 4/16. Not until 3 PM did less than a majority of respondents report problems as shown in Figure 4.

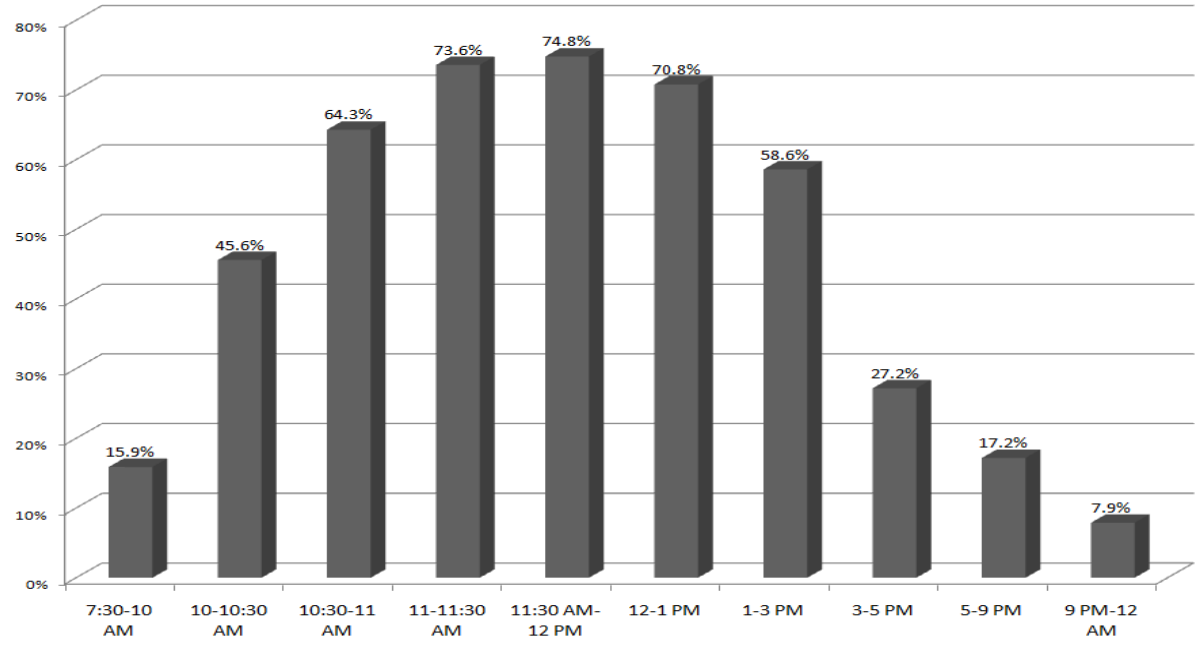


Figure 4. Connection Problems over Time

There is one main wireless cell phone service provider in the Blacksburg area, Verizon Wireless. Most residents subscribe to Verizon Wireless. Other providers have a presence, including T-Mobile, AT&T, Nextel and Cingular, but they have less coverage and reliability. Verizon Wireless increased its capacity throughout the

late morning and early afternoon as its network became saturated, but it was not able to accommodate total demand during the peak period of the crisis between 10:30 am and 3 pm.

DISCUSSION AND IMPLICATIONS

The communication of VT students, faculty and staff showed heavy use of voice and text messaging from cell phones and email from computers, as part of a mix of communication and information media during the tragic day of 4/16. Most communication was with users' strongest social ties, such as family members and close friends. They communicated earlier and more frequently with stronger ties than with weaker ones. We expected to see these kinds of patterns. We were particularly interested in the use of text messaging from cell phones, as this is one of the most bandwidth efficient forms of communication. Efficient use of bandwidth is especially critical during emergencies, when networks become quickly saturated and many calls can fail to connect or get dropped shortly after connecting.

It is clear in this study that text messaging was used representing 11% of all contacts, however it was voice communication dominated the use of cell phones. Students, particularly undergraduates, used text messaging the most. Moreover, they used it not with all their strongest ties but only with their strong ties who also generally use text messaging, that is, other young people (their siblings, close friends, friends and romantic partners or spouse).

The significance of this finding is that there seems to be a need to increase familiarity and acceptance of texting. In terms of bandwidth usage, we could improve the network performance by greater use of text messaging in emergencies than voice communication. However, since older adults are less familiar with text messaging, they are less likely to use it in general. While there is some tendency among older adults to use new technology less than younger adults, the use of text messaging in the United States seems to be further inhibited by the fees charged by cell phone service providers for individual text messages.

It is important to note that the current high charges for text messaging (e.g., 20 cents per message whether sending or receiving with Verizon Wireless) are a disincentive to subscribers to learn this simple but potentially essential communication capability. Our thinking is that it is important that there be incentives for cell phone subscribers to learn how to use text messaging (such as, a certain number of free text messages per month with any subscription), so that in the event of an emergency, subscribers are not trying to use text messaging for the first time to notify kin or rescue authorities. Another possibility is advances in voice recognition, but this is not the focus of our research. Ultimately, we might recommend that cell networks be designed for emergency loads or preferential access to emergency responders, however, we do not want to foreclose the communication that is vital among ordinary citizens in situ during an emergency.

Texters in our study differed significantly from non-texters on many variables, not only the amount of texting on an average day but also the amount of dropped connections or other network problems on 4/16. These differences, however, are largely due to the predominance of students in the user population. Nonetheless, a similar university environment should expect to have the same population distribution and cell phone usage patterns, since students are the predominant user population on campuses.

The tragic events at Virginia Tech on April 16, 2007 can be considered a combination of crisis informatics and social convergence events. It is a crisis in that some people were under attack from a lone gunman; the subsequent attempts to obtain information and account for people's safety are a social convergence event, insofar as a large number of people are communicating with each other and with people who are in other locations (home, other parts of the city, other cities, and abroad) who have an interest in what the individual participant is seeing and doing. Given the finding of Hughes and Palen (2009) that people who adopted twitter during a crisis or social convergence event continued to use the service, and given the unfortunate recurrence of campus shootings, we can expect to see an increasing use of text messaging by older users (e.g., university and college faculty, staff and parents of students) for crisis informatics and social convergence in similar situations.

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