A Large Scale Study of Text Messaging Use

Agathe Battestini, Vidya Setlur, Timothy Sohn
Nokia Research Center
955 Page Mill Road
Palo Alto, CA 94304 USA
{agathe.battestini,vidya.setlur,tim.sohn}@nokia.com

ABSTRACT

Text messaging has become a popular form of communication with mobile phones worldwide. We present findings from a large scale text messaging study of 70 university students in the United States. We collected almost $60,000$ text messages over a period of 4 months using a custom logging tool on our participants' phones. Our results suggest that students communicate with a large number of contacts for extended periods of time, engage in simultaneous conversations with as many as 9 contacts, and often use text messaging as a method to switch between a variety of communication mediums. We also explore the content of text messages, and ways text message habits have changed over the last decade as it has become more popular. Finally, we offer design suggestions for future mobile communication tools.

Categories and Subject Descriptors

H.5.m [**Information Interfaces and Presentation (e.g., HCI)**]: Miscellaneous

General Terms

Human Factors

Keywords

Short Message Service (SMS), text messaging, mobile device, texting, large-scale study

1. INTRODUCTION

Text messaging is a method for sending short 160 character messages between mobile phones that has become a popular, global method of communication. In the past decade, text messaging use has grown from 12 million to 135 billion messages sent every month [1]. The popularity of text messages can be attributed to a variety of factors, such as cost per message compared to voice minutes, social appropriateness, ease of use, and the lightweight nature of sending messages [8, 4, 17]. Text messaging use has also increased as a result of interaction with online services such as bank statements, social networks, and chat clients.

There are differences in text messaging use around the world, and numerous studies have been conducted in countries such as Germany [2], Finland [9], Norway [11], United Kingdom[4] and Japan [8]. The earliest text messaging studies were conducted in Norway, examining the shift from voice to text in teenagers' mobile phone usage [11]. Since then, text messaging has been explored in many countries, but few studies have been conducted in the United States [13]. These studies explored the motivation behind adopting text messaging as a dominant communication medium and provided details about how text messaging was being used.

There have been several notable pieces of work in the research literature. Grinter and Eldridge offered some insights into the content and character of texting among a small group of British teenagers [3]. They reported findings that teenagers tend to text for three primary activities (chatting, coordinating and planning). Given the immediacy and mobility of text messages, Kasesniemi and Rautiatainen found that text messages started to resemble online chat in turn taking and discourse structure [9]. In a questionnaire study of British and American texters, Reid and Reid found a difference between 'texters' and 'talkers', with 'talkers' being much more active in conversations and frequently participating in simultaneous text conversations [12]. Our work explores these issues further through an analysis of a large-scale text messaging data set.

In this paper, we present a comprehensive analysis of a 4-month text messaging study conducted with 70 students at an American university. Our work complements the aforementioned studies and expands on the broad range of text messaging use. Unlike previous studies that rely on self-reporting through diary studies and questionnaires, we instrumented each participant's phone with a logging client that captured all incoming/outgoing text messages along with location information of where the texts were sent or received. We collected a total of $58,203$ text messages logged from participant's phones between December 2008-April 2009. The dataset we collected gives us a unique opportunity to contribute additional analysis to previous text messaging research. Our findings reveal that participants text with a large number of contacts, often have several simultaneous conversations through texting, and use text messaging to switch between multiple communication services. Although previous research has identified that texters engage in some of these behaviors, we present further analysis through a large dataset to understand the topics of text message conversations and how simultaneous conversations occur. Based on our findings, we make several suggestions for designing future mobile communication technology.

2. METHODS

There are many methods to capture data from participants in situ. Previous SMS studies have used a variety of diary study methods that involve the participants keeping a journal of their SMS activities [3]. Diary studies help capture real data in the moment, but suffer drawbacks of potentially missing data because participants forget to record an entry. Another possible method is direct obser-

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vation, but this can be quite time consuming and would not capture data in certain parts of the day when the observer is not present.

We chose to collect data through a custom logging tool installed on the participants' phones. In contrast to a diary study where some messages may not be recorded, we were able to capture all text messages on the device. The logger recorded each incoming and outgoing SMS message along with the location (via GSM cell positioning [10]) where the message was sent/received. Participants interacted with the native text messaging application, but were aware that a logger was running on the phone. We enabled several privacy features on the phone so that participants could control the text message logger; turn off location monitoring or message gathering altogether. Text messages were uploaded to our central server each day and posted on a website for the participants to see their messages. If the participants did not want certain messages to be included in our analysis, they could delete the messages from our system through the web interface. Our analysis and results do not include any deleted messages.

2.1 Participants

Our study took place at a local university in the United States from December 2008 until April 2009. We recruited 70 participants (48 male, 22 female) through flyers and online mailing lists. Participants were all undergraduate or graduate students at the local university studying a variety of majors such as economics, arts, communications, computer/political/environmental science, biology, linguistics, film, international relations, product design, electrical/mechanical/bio engineering, architecture, classics, and education. We recruited over a wide range of college students to gain a broader understanding of text messaging use in the university community. Although our participants come from a select sample of university students, they help provide insights into novel uses of text messaging. As text messaging continues to grow, we believe many of these behavioral patterns will carry on with these students from the university campus to the workplace.

All the participants owned a mobile phone and were experienced with text messaging. Ages ranged between 17 to 26 years ($mean = 20.36$ years, $\sigma = 1.92$ years). Participants had an average of 6.26 years ($\sigma = 2.51$ years) of experience with a mobile phone. They were also proficient in text messaging, with an average of 4.54 years ($\sigma = 2.3$ years) of experience.

2.2 Procedure

We collected data from our participants through an initial online survey and text message logging tool on the phone. The survey asked each participant about whom they text with, why they text, and general attitudes towards text messaging. After the survey, we gave each participant a Nokia N95 to use with our pre-installed logging software. The participants were all required to have SIM cards that they could easily transfer into the N95 phone. As phonebooks can be saved to the SIM cards, the participants all had access to their phonebook data from their previous phones. We asked the participants to use the study phone as their primary phone for the entire 4 months of the study. Most participants already had texting and data plans, but 10% of them did not have the unlimited plan needed to cover the sending and uploading of SMS data to our servers. At the time of this study unlimited text plans averaged $15 USD per month and unlimited data plans averaged $20 USD per month. Instead of reimbursing the cost for an unlimited text and data plan, we compensated the participants by letting them keep the phone ($\approx$ $400 USD) at the conclusion of the study. The cost of the phone covered the charges incurred for the text/data plans and included additional compensation for their participation in the study.

All participants were asked to sign a consent form acknowledging that their text messages would be logged and later used for research analysis. Consent was mandatory before participating in any part of the study. We strongly encouraged the participants to also notify any third parties that they communicate with about their participation in our study. Third party consent is often a difficult issue, thus we created mechanisms for our study participants to remove messages that any third party did not consent to. Further, the names of the participants mentioned in our paper are pseudonyms.

3. SURVEY RESULTS

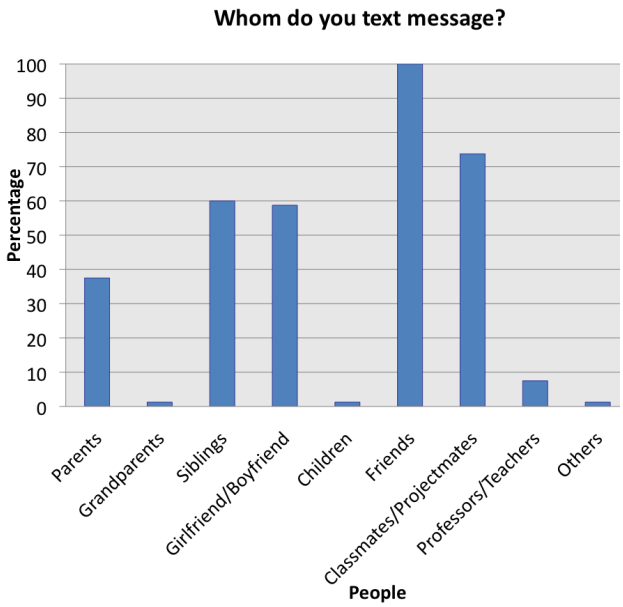


Figure 1: Percentile breakup of people with whom the participants typically text message, based on an online survey. Texting is used for a wide variety of recipients. Friends have the highest occurrence at 100%, classmates/projectmates are ranked second at 74%, and siblings ranked third at 60%.

We conducted an initial online survey with the participants as a means of self-reporting, asking questions about their normal texting usage and attitudes. Figure 1 shows the percentage of participants of whom participants reported that they send text messages. All participants responded that they send text messages to their friends, which is consistent with previous studies [11, 4]. Classmates and projectmates were ranked the second highest at 74%. Siblings ranked third at 60%. A number of participants indicated that they exchange text messages with their parents (37%). This number is higher than previous reported numbers and suggests that text messaging is becoming a popular method for interfamily communication. Professors and teachers were also recipients of text messages, using the method as a way of communication for class.

We asked participants to respond to 14 questions about their general attitudes towards text messaging using standard communication research scales for interpersonal communication motives [15] and affinity [14]. Figure 2 shows the results from these questions. One of the classic mobile phone problems is text input. Participants responded that they generally use abbreviations and predictive text while text messaging. Although abbreviations can help lower the

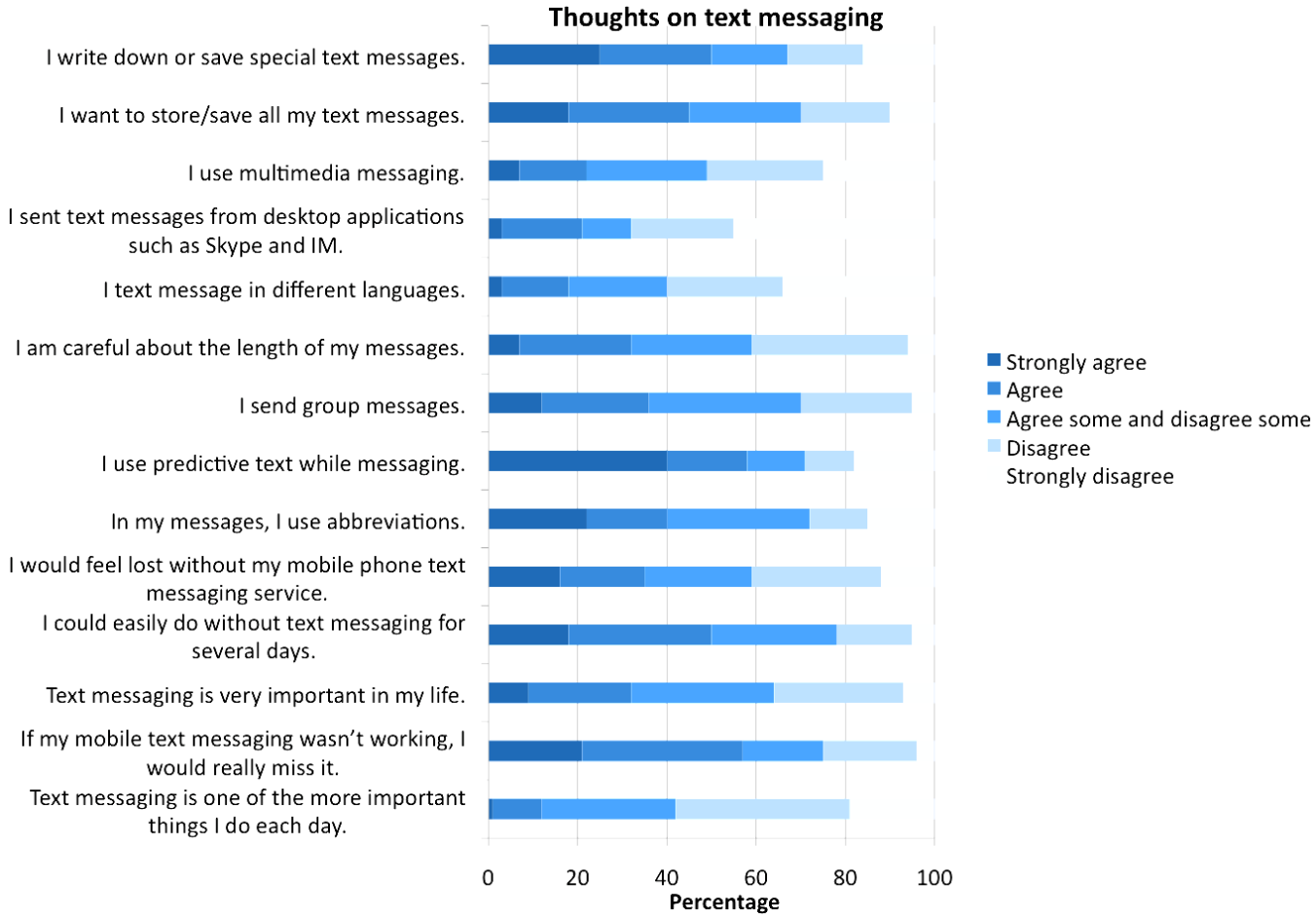


Figure 2: Plotting general attitudes of text messaging usage.

character count, more than 40% of the participants indicated that they are not careful about the length of their messages.

Participants indicated that they often send group messages to multiple recipients. Although this is not naturally supported in the SMS protocol, we found both in the survey and logging study that group messages are an important part of daily communication. Group messages were also some of the initial messages that started simultaneous conversations with friends. We describe some examples of this in our logging study results.

Many of the respondents indicated that they would like to write down or save text messages that are special. Taylor and Harper have described similar sentiments through the embodied meaning behind text messages [18]. Over 60 % of the participants responded that they would miss text messaging if it were not working. However, few participants considered text as one of the more important things they do each day. Very few participants text in different languages or sent text messages from desktop applications. Finally, most respondents seem to use more basic text messaging features and less of multimedia messaging.

In the last part of our survey, we explored some of the motivations behind texting (Figure 3). We asked the participants why they send text messages, and provided twenty possible responses for them to rate. Most respondents send text messages more for its utilitarian benefits (e.g. to reply to a question, to announce something, to request something from someone, to ask where somebody is, to plan a meeting), and less for its emotional benefits (e.g. because it's exciting, because it makes me feel less lonely, to gossip, let others know I care about their feelings). Using Principle Components Analysis, we found that all but one of the motivations items (escape, pleasure, inclusion, relaxation) and affinity measures form a single and highly reliable factor (Cronbach's α = .96). By averaging the scores on those items, we created a single positive orientation toward text messaging factor. The affection and control motivations did not fit into this factor. By regressing number of years of texting experience upon this positive orientation toward text messaging factor, we found that numbers of years of texting experience predicted a negative orientation toward texting among respondents to our survey (model R^2=.64, b=-.80, $p < .05$). The number of years of experience of texting did not significantly predict an orientation toward controlling others or seeking affinity with others. This suggests that the people who had more experience with text messaging tend to use it more often, but they did not not seek escape, pleasure, or relaxation from it.

The survey results provide some initial insights into the text messaging usage patterns of the study participants and their perceived opinions about text messaging. This information along with the quantitative analysis described further in the paper, can help motivate informed design choices for text messaging interfaces regarding what users presume and their actual behavioral patterns.

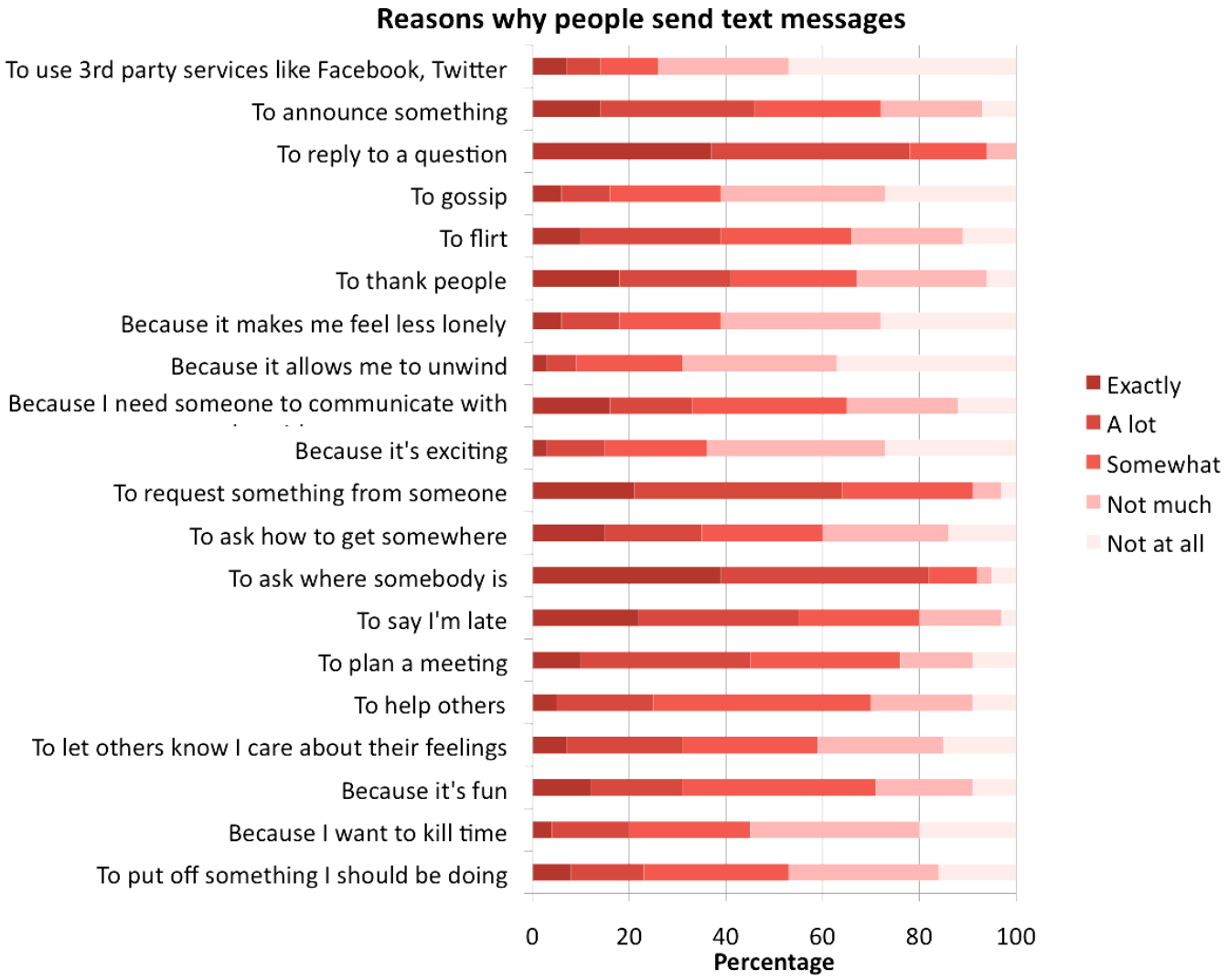


Figure 3: Plotting responses to why people send text messages. Respondents tend to send text messages more for its utilitarian benefits and less for its emotional benefits.

4. LOGGING STUDY ANALYSIS

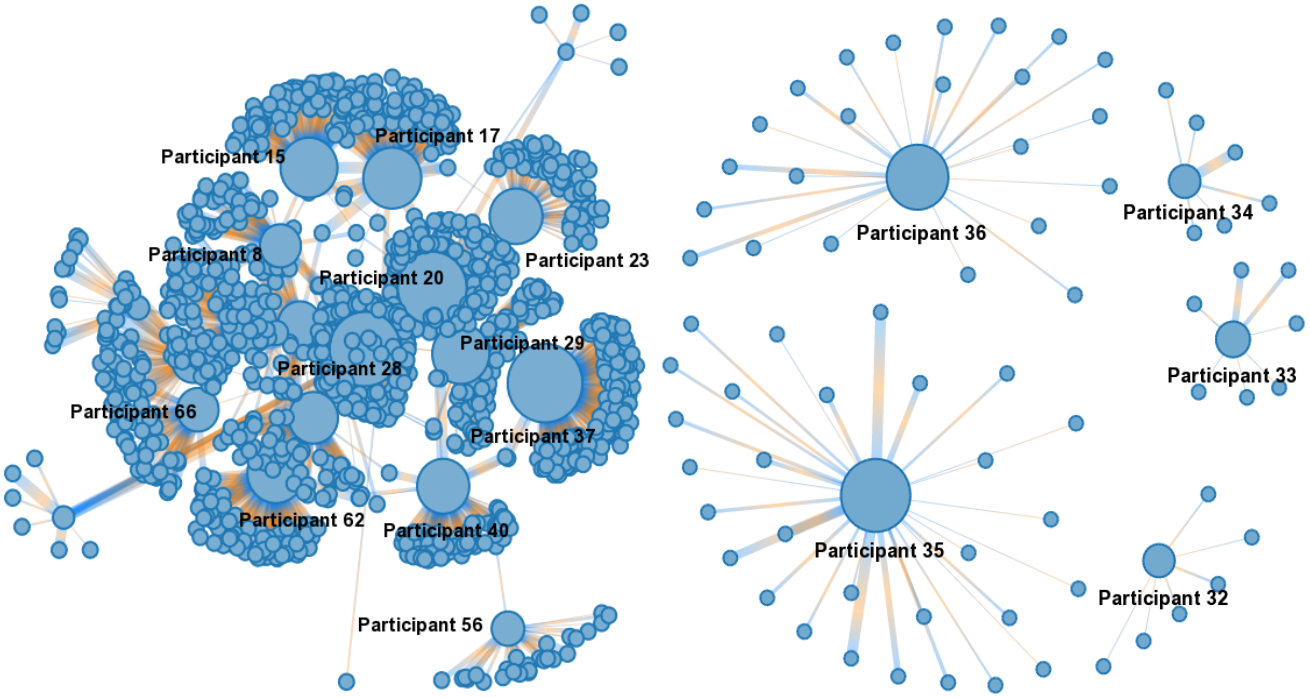
The participants sent a total of $58,203$ messages during the study ($24,806$ outgoing, $33,397$ incoming). There were an average of 848.6 messages exchanged during the study by a single participant ($\sigma = 1000.5$, $min = 7$, $max = 5304$). The average time to reply to a text message received or receive a reply to a text message sent was $6:04$ minutes.

We did not find significant gender differences. Female participants communicated slightly more than male participants with an average of 862 messages per female user ($\sigma = 974$, $min = 26$, $max = 3522$) versus 817 messages per male user ($\sigma = 1000$, $min = 7$, $max = 5304$). Text messages sent by female participants were also slightly longer with an average of 58 characters ($\sigma = 48$, $min = 1$, $max = 513$) versus 47 characters ($\sigma = 44$, $min = 1$, $max = 517$) for male participants. Hoflich and Gebhardt also noticed that women send more and longer messages than men, but their results showed a more significant gap between genders [6].

4.1 Text Message Conversations

Our logging tool captured both incoming and outgoing messages sent by each participant. The lightweight nature of text messages means that all messages are treated as single units, even though they may form part of a larger conversation between two individuals. To address this, we applied a conversation grouping algorithm to all of the messages. Messages that cannot be grouped into a conversation are treated as single messages (e.g., messages without responses).

We define a conversation as two or more text messages exchanged between contacts with at least one incoming and one outgoing message. We applied a conservative time metric of a 20 minute response time in order to group messages together. If a message between two individuals was followed with another message within the 20 minute window, the messages would be grouped together as a conversation. Our algorithm identified a total of $8,590$ conversations with an average of 122.7 conversations per user. The average conversation contained 4.93 text messages exchanged between contacts. We found that there is a strong correlation (correlation factor = 0.95) between the total number of text messages sent and the number of conversations a user was engaged with. In total, 72.8% ($42,390$ messages) of the total messages were part of a



(a) Messaging network of 1255 users (pilot participants and their contacts) from the study dataset

(b) Zoomed in view of a portion of the messaging network

Figure 4: Visualization network of the text messaging data. Here, each node denotes a user. An edge between two nodes indicates that a text message was sent between two users. A single text message is denoted by one line as the edge. A blue edge indicates an outgoing text message, while an orange edge indicates as incoming message. If two nodes text message to one another, then the orange color would appear roughly in the middle of the edge. A conversation is denoted by the thickness of the edge. Thicker the edge, the more back-and-forth text messages there are in a given conversation.

larger conversation and 27.2% (15,813 messages) of the messages were single messages.

4.2 Categorizing Conversations

A large dataset of text messages provides a unique opportunity to explore the topics that are often discussed in text message conversations. Three researchers independently categorized 35% (3,000 out of 8,590) of the conversations, tagging them with words that identify the content and purpose of the message. We chose only to do a subset of the conversations given the overwhelming number of conversations. We believe that this subset still maintains insights into the broader set of data.

After all three researchers categorized the subset of data, we grouped the tags into higher-order categories. Each conversations was then given votes based on which category each researcher had placed them in. If a conversation had two or more votes, then it was classified into the appropriate category. Some conversations spanned multiple topics and could be placed in multiple categories if there were enough votes to do so. These categories only reflect what we observed through this study and are not meant to be an exhaustive list. Moreover, our study only captures a population of college students, but still offers insights into behaviors and patterns for text messaging use. Table 4.2 shows each category, a representative example taken from the conversation subset, and the number of conversations in that category.

Planning (31.7%) accounted for almost a third of the conversation topics. Many of these conversations were related to planning future events/get togethers, coordinating around meal times, and organizing rides. Given the lightweight nature of text messaging, coordination is a popular use to send quick messages back and forth. Previous research has also observed that planning and coordination are dominant topics among teenagers [3]. Our results indicate that this topic is similar among college students.

Relationships (15.3%) were the second most frequent topic of conversation. These conversations involved gossip about others, 'thinking of you' type messages, and discussions about deep relationship issues. We observed several fights and breakups between significant others that were communicated over text messaging. The conversation with the most messages lasted 3 hours 39 minutes between two significant others flirting from the morning until afternoon. The entire conversation contained 108 text messages (every 2 minutes).

Chatting was a popular use for text messaging. We categorized messages that did not have a clear topic of conversation into this category. Examples included conversations asking "what's up", "how's it going", and "good morning". The longest conversation our algorithm discovered was 7 hours 58 minutes and was categorized in this category. The conversation consisted of 38 messages (every 12 minutes) sent between friends discussing their life and making weekend plans (also listed in the planning category).

All our participants were part of the university community and would sometimes discuss school and job related information through text messaging (10.9%). Text messaging was popular for announcement, such as when practice would be or what time a fraternity gathering was happening. Students also used text messaging to discuss homework answers with each other. A secondary topic

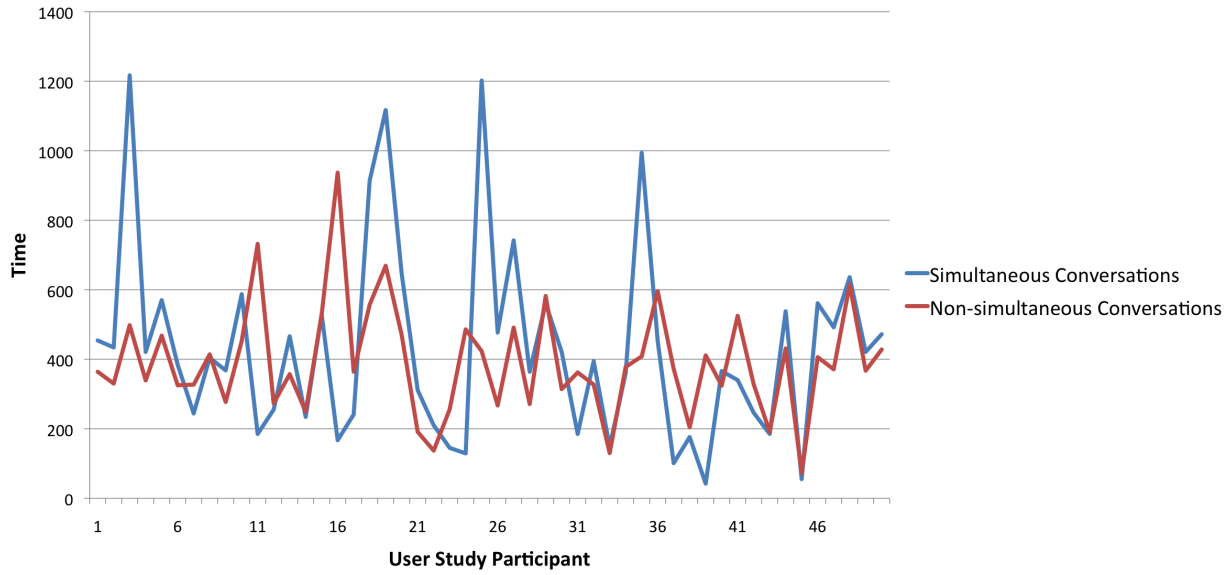


Figure 5: Trend lines of average times to respond to simultaneous and non-simultaneous conversations.

that is popular among university students is food, which accounted for 9.5% of the conversations.

Places (10.2%) and Information Seeking (10.2%) had an equal amount of frequency and are both closely related to mobile information needs. Conversations about places typically involved letting others know one's location or querying others to know their location. In a study of mobile information needs, Sohn et. al. observed that information about friends and places were a frequent type of information sought after by mobile users. Moreover, they also observed that people would call a friend to address their information needs, which is represented in our study through text messaging. Information seeking through text messaging others has a unique way of being asynchronous and allowing recipients to respond at their convenience.

With the popularity of social media that encourages broadcasting status messages to the world, we found text messaging an interesting place to selectively broadcast these messaging. Current status messages (9.0%) through text messaging naturally afford picking the recipients that know what you are doing. Other related topics to current events included Sports/TV/News (6.8%) that were about scores for ongoing sports games and newsworthy topics.

Communication (5.3%) was an interesting use of text messaging that we believe provides insights into the future design of mobile technology. Text messages conversations in this category involved continuing conversations from other communication mediums, such as responding to emails, Facebook messages, or phone calls. Some participants would move to text messaging if a conversation needed to switch from online chat to mobile, or they wanted to share email/web addresses with each other. This category of conversations reveals that users communicate with each other across a variety of services, and text messaging is often used as a mediator between them. Creating an easier way to switch between these communication services could be a great benefit for mobile users.

Illicit Activities (2.9%), Health (1.7%), and Money (1.1%) round out the list of categories and were discussed with low frequency.

4.3 Simultaneous Conversations

Given the large percentage of messages that were part of a conversation, we assumed that there would be a number of simultaneous conversations that occurred. Participants engaged in a significant number of simultaneous conversations, sometimes with as many as 9 different contacts. Figure 4 shows a network snapshot of messages sent between people during the study. In the figure, each node represents a user. An edge between two nodes indicates that a text message was sent between two users. A single text message is denoted by one line as the edge. A blue edge indicates an outgoing text message, while an orange edge indicates an incoming message. If two nodes text message to one another, then the orange color would appear roughly in the middle of the edge. A conversation is denoted by the thickness of the edge. A thicker edge represents more back-and-forth text messages there are in a given conversation. From Figure 4b, even though it represents a subset of the data, we can see that significant number of conversations occur between users based on the thickness and colorations of the edges. These conversations also occur with numerous people as evidenced in the subset of participant 35 (Figure 4b).

Simultaneous conversations were a significant part of our participants text messaging habits. Despite a text messaging interface that does not explicitly support multithreading messages, we found numerous simultaneous conversations in our dataset. We define a simultaneous conversation as two or more conversations overlapping in time. Previous studies have rarely observed simultaneous conversations in text messaging [3], but have seen this type of behavior in instant messaging use [5, 16]. IM studies have reported that simultaneous conversations only occur with a handful of contacts. Our results suggest that simultaneous conversations are becoming more frequent in text message conversations.

Given many of the traditional problems with mobile interfaces (i.e., screen size, input) we did not expect users to be able to carry on so many conversations at once. This behavior is interesting because text messaging clients on mobile phones are not designed like IM clients. Most desktop messaging clients can take advantage of larger screen space so multiple conversations can be viewed at once. In contrast, the text messaging interface of most mobile phones (particularly the phone used in our study) only allow the user to view one message at a time. Despite these constraints, some of the conversations in our study were with as many as 9 unique contacts at a time. Using the same metric for detecting conversa-

Category	Number of Conversations	Percentage	Example
Planning	951	31.7	**out:** "What time are you leaving for class" **in:**"Im at the dining hall. I'm leaving straight from here at like 1:05?" **out:** "Okay"
Relationships	460	15.3	**out:** "Hey. I thought about u today'" **in:**"Aww thanks that so sweet , did you really think of me so cute" **out:** "Yes i did cuz u werent answering :(awwww i wanna cuddle"
Chatting	412	13.7	**out:** "How's LA? did you really wake up at 8?'" **in:**"Hehe got to my house at 9:30 so i got up at around 9. LA is good"
School/Jobs	326	10.9	**out:** "When are our presentations due?'" **in:**"Like in 2 weeks? Or maybe next week"'
Places	305	10.2	**in:** "Hey i'm in the french house where you at?'" **out:**"Dance floor away from the doors"' **out:** "We are leaving. You ok?" **in:** "Yep i'm with people walking"
Information Seeking	305	10.2	**out:** "Who was that artist you put on in the cluster last night?'" **in:**"Bon Iver."'
Food	285	9.5	**out:** "Im hungry i want orange chicken lol'" **in:**"i'm coming over right now"'
Current Status	270	9.0	**out:** "Where are you?" **out:**"Denzel washington is in the crowd!!!"' **in:**"I am on the tv platform. Hopefully I don't get kicked out."'
Sports/TV/News	205	6.8	**out:** "Whats the score?" **in:**"3 and a half minutes left uconn up by 5"'
Communication	159	5.3	**out:** "Yo can u email me those ids when u can" **in:**"Whats your email?"'
Illicit Activities	86	2.9	**out:** "We headed home now? Got some to smoke" **in:**"Yup"'
Health	52	1.7	**out:** "I have obstructive sleep apnea... :(" **in:**"?"' **out:**"From the sleep clinic..."'
Money	33	1.1	**in:** "I need to pay my mom back tomorrow :)" **out:**"Haha whoops i forgot. How much do i owe?"' **in:**"I'm not sure, ask carla (she kept the check)"'

Table 1: Categories of a subset of conversations. Here, incoming text messages are prepended with 'in:' and outgoing text messages are prepended with 'out:'

tions described above, we found that each participant had an average of 7.9 simultaneous conversations ($\sigma = 12.1$, min=0, max=57) during the study. The top 5 users all engaged in 30 or more simultaneous conversations.

There were 554 simultaneous conversations during the study. These conversations can overlap in a natural way as text messages are sent and received with different contacts, but they can also be initiated by a multi-recipient text message. 56% of the simultaneous conversations were initiated with a multiple-recipient text message. The text messaging application on the N95 phone lets the user compose a message and select multiple recipients. Unlike email that shows a full recipient list, text message recipients will not be able to see who the text message has been sent to. The following conversation shows a user trying to find out who is coming to his party by sending out a single message to 8 contacts:

Alice	*Are yall coming tonite?*
Response 1	*I just woke up from a nap and I need to work on my ihum essay. Its a night-in for me :(*
Response 2	*Yea. Are you already there?*
Response 3	*Yup*
Response 4	*Hells yeah! Is it poppin?*
Response 5	*Coming now.*
Response 6	*Isabelle anton and i are coming soon*
Response 7	*I'm sick have fun tonight!*
Response 8	*We are heading over as we speak*

4.3.1 Variety of Simultaneous Conversations

The conversation highlights a message with a quick response that others can respond to. There were a number of conversations that began with a more open-ended text message, which led to several longer conversations. Table 2 shows several topics of simultaneous conversations that were started with a multi-recipient text message.

Some messages prompted short conversations such as sports scores. A number of categories spawned several simultaneous conversations because of their more open-ended nature. One of the big incidents that occurred during the study was a participant's dorm room being robbed. She sent text messages to 4 contacts that in turn spawned conversations with each one. The conversations lasted for the next four hours. Interestingly, the conversations never transferred over to face-to-face or any other communication medium during that time frame. We believe that this may suggest text messaging is becoming both a common and preferred method of communication for some individuals.

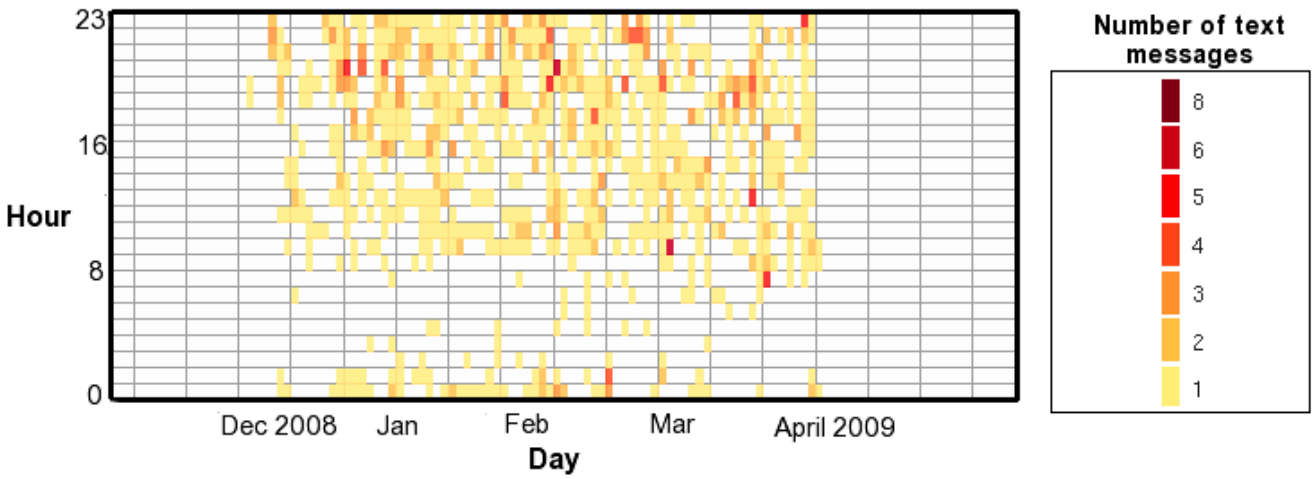


Figure 6: Time chart of a user across the duration of the study. Notice that the frequency of text messages is higher towards the evening and night, probably typical of a student.

Category	Example
Future Plans	*Where are y'all? You are making 012 look bad. C'mon. 680 is where its at!*
Sports Scores	*WE WON 84 66 AWESOME AWESOME GAME!!!*
General Greeting	*Hey u good morning. Whats up?*
Thanks	*Hey girls thanks so so much for coming tonight! It meant so much to me to have u both there! :)*
Big Incidents	*My room got robbed*
Looking For Items	*Hey do you know anyone with a truck or large van that would maybe let me borrow it 2m to move into my apartment in monterey?*
Announcements	*Practice moved to tomorrow, Meetings are today at 2:30 still*
Future Communication	*hey call me at thls number my phone is ab to die and i need to talk to u ab something important*
Chain Letter	*If I LeT u GRAB 1 pArT oF My BoDy WhaT pArT WouLd u GRAB?? Keep this going to both sexes! And see what u get back*

Table 2: Categories of simultaneous messages

There were several chain letter messages in our dataset that we were surprised to find (Table 2). Chain letters are typically associated with email, but it seems they have started to make an appearance in text messaging. The content of these chain letter messages included topics that were sexual in nature, and about bringing good luck if passed along to several friends. It is unclear how far the chain letter was passed on, but it was interesting to see this type of use.

4.3.2 Simultaneous Conversation Response Times

We were surprised at how users were able to handle these simultaneous conversations on their mobile phone. We analyzed the dataset to assess how well people multitask when they have simultaneous conversations with different contacts. 50 users in our dataset had both multiple simultaneous conversations, and multiple non-simultaneous conversations. Across all users, the average time to respond during simultaneous conversations was 431.28 seconds ($min = 42$ seconds, $max = 1217$ seconds, $\sigma = 274.453$ seconds). The average time to respond for non-simultaneous conversations was 391.88 seconds ($min = 72$ seconds, $max = 937$ seconds, $\sigma = 156.141$ seconds). There are a variety of factors that affect response time; participants could be driving, in a meeting, or missed a text message notification. In general though, we noticed that users tend to take longer to respond to an incoming text message when they are engaged in conversations with multiple contacts (Figure 5).

4.4 The When and Where of Conversations

4.4.1 When Conversations Occur

Figure 6 shows a time chart of when participants sent/received text messages. Many of the participants being students sent text messages towards the end of December, which coincides with finals and winter break. This pattern also occurred near the end of March when the next school term ends and spring break begins. The topics of conversation during these time periods often related to final exams, school work, and procrastination.

We generally found that text messages were sent/received towards the evening and night time. This is probably representative of most participants in our study who were students. Some messages were sent in the very early hours of the morning when participants stayed up late. There were several occurrences of a higher number of messages sent in the morning between 7 a.m and 10 a.m. Many of these messages were general greeting messages (Table 2) that started several conversations.

4.4.2 Where Conversations Occur

The ubiquitousness of text messaging enables people to communicate from anywhere. Our study spanned several vacation periods in the university quarter, so students traveled to many different places across the country. Text messages were sent from 20 different states, but most of them were sent in the area around the

university. We were particularly interested in where conversations occur - how much movement there is during a conversation. We analyzed each of our 8590 conversations for any cell id changes from our participants during a conversation. We considered cell id changes to indicate that the participant was moving while maintaining a conversation. In 87% of the conversations we found that users did not move, in other words, they stayed at the same cell id. This may have implications for designing around mobility for text messaging, particularly for conversation threads.

4.5 Text Message Lengths

With the changes in text message usage, we wanted to see how the 160 character limit would affect messages. Modern phones have recently begun to abstract the character limits from the user by automatically deconstructing and recombining messages that exceed the character limit. This can help provide a seamless experience for the user since she does not need to think about how to partition each text messages. Not all phones automatically partition messages though, so users still need to be conscious about how messages are going to be seen by the recipient.

The majority of messages sent in our study were within the character limit. Participants sent or received an average of 50.9 characters per message ($\sigma = 46.2$ characters). 2.4% of the messages (1373 messages) exceeded the character limit. In our initial survey results (Figure 2), almost 50% of our participants indicated that they are not careful about their text message lengths. Given some of the novel uses of text messaging, we witnessed many messages that exceeded the 160 character limit. One individual sent an 11-part message with each text averaging 505 characters. The longest message had 520 characters, 3.25 times the length of a single text message.

> *Yeah but will you like me if I call it off??? and will you still like me if I do what my parents say....???....if I decide to like you and be your friend...be your campanion ratheer than your girlfriend and in a relatikonship??? ...if I call it off to be "lovers" and title it companionship I feel like you won't like me :(...I tried to stand up to them but to be honest I'm scared. This is stressing my mom. Daniel has a gf it turns out...she just found out I was lying to her and she was on verge of breaking*

We are not sure what compelled the participants to send such long messages over SMS, but believe a lot of the motivation may be due to the immediate nature of text messaging. Email may be better suited to handle these messages, but previous studies have reported that a contact is more likely to check a mobile phone rather than email [3]. This trend may be changing though with the pervasiveness of mobile internet access.

5. SMS CONTACTS

Previous mobile phone studies have found that address books are often filled with many contacts, but only few are actually involved in any communication and an even smaller number in SMS communication [3, 7] . We found similar results on a larger scale. Whereas Grinter and Eldridge reported that participants text with $10 - 15$ individuals [3], our study participants had text message conversations with an average of 47.1 different contacts ($\sigma = 35.3$, $min = 3$, $max = 148$).

Not all contacts were involved in regular communication. We analyzed the dataset to find regular contacts based on frequency of communication. We considered a contact to be a regular contact if messages were exchanged on at least 10% of the days during the study (12 days out of 121 total days). As text messaging is only one method of communication in the grander setting of other conversation tools, we considered 10% a good metric for determining if one was a regular contact. 51 participants had regular contacts with an average of 5.2 contacts ($\sigma = 4.1$, $min = 1$, $max = 18$). Of all regular contacts, participants communicated with them an average of 25.3 days ($\sigma = 14.5$) for the duration of the study. One participant communicated with his most frequent contact for 99 days of the study.

These results suggest that text messaging has grown to be a common practice even with acquaintances, based on the number of contacts that our participants corresponded with. We believe that this may be because our study was conducted among university students who are in an environment that is more conducive towards communication (e.g., classes and social events). This would naturally increase the amount of text messages exchanged with others based on ongoing activities. Although text messaging is used to communicate with many more contacts, there is still a select handful of contacts that people communicate with frequently.

6. TEXT MESSAGES AND SERVICES

One of the upcoming uses of text messaging is interaction with web services. Popular social networking services lend themselves to having a natural mobile component. Services such as Twitter and Facebook that rely on users sending status messages benefit greatly from a mobile interface. With the plethora of heterogeneous mobile phones, finding a common denominator to provide access to these services is difficult. Text messaging is the natural candidate for these web services because it is ubiquitously available on all mobile phones. The cost of text messaging is also decreasing, which makes it a more viable candidate for wide adoption.

We had $1,059$ messages (1.8%) that were associated with a web service (e.g., Twitter, Facebook). Although the number of messages seems small compared to the total number of messages collected, we had a significant number of participants (89%) interact with web services through text messaging. Some examples of these web services included mobile banking (balance information), status updates, and instant messages. The interaction with services demonstrates a different way that text messaging is being used. In the case of status updates to a public social networking site (e.g., Twitter) a text message is a broadcast as opposed to a point-to-point message like traditional text messaging. We have already seen that text messaging is used to send messages to multiple recipients, even though the technology was not designed for such uses. The availability of web services that broadcast helps complement the different types of communication available using text messages. In the future we would like to explore some of the motivation behind using these broadcast type services from a mobile device and compare them to other uses of text messaging.

7. DESIGN IMPLICATIONS

Our study results indicate that text messaging has evolved in many ways over the last decade. Text messaging has become an essential and sometimes preferred method of communication. Based on the observations in our study, we offer two design suggestions for future designers of mobile communication tools.

First, mobile communication tools should consider supporting simultaneous conversations. Our results show that users often communicate with multiple contacts on their mobile device. Multithreading habits over instant messaging are common on desktop computers with chat interfaces, but become more difficult to sup-

port on a constrained mobile device. There are several chat clients available on phones today, such as Nokia Chat. These chat clients are similar to their desktop counterparts, but are still designed with one conversation thread in mind. Users are unable to start a multi-recipient message and then maintain these messages as responses arrive. Users need a way to manage simultaneous conversation threads when initiating them. 56% of the simultaneous conversations started with a multiple recipient message and had to be managed as single messages.

Second, we noticed messages involve other communication channels such as responding to Facebook messages, sending web addresses, or continuing conversations from SMS through online chat. We believe that this provides support for exploring interoperability between different communication mediums. We imagine that as mobile phones become more capable and have access to a wide range of messaging technologies, users may want an easy way to manage these multiple communication mediums. We imagine future interfaces integrating these technologies together so that conversations can seamlessly continue from online chat to SMS and then to another medium such as email. There are concerns about maintaining these seams since different technologies may have different social implications. Also as evidenced through our analysis of text message lengths, users are not always careful about the 160 character limit inherent to SMS. Providing a way to switch to appropriate message delivery methods would be useful to address some of these limitations.

8. CONCLUSIONS

Text messaging has become a popular method of communication that has encouraged a variety of novel uses. The current trajectory of text messaging seems to indicate that this communication medium will continue to grow as text messaging habits transfer from teenagers, college students, and into the workplace. We have presented an in-depth analysis of text messaging use in the daily lives of 70 university students over a period of 4 months. Using a custom logging tool on the participants' mobile phones, we captured $58,203$ text messages grouped into $8,590$ conversations. Categorizing a subset of these conversations our study revealed that text messaging has several novel uses such as continuing and responding to conversations from other services (e.g., email, instant messaging). Our study also showed that participants engaged in simultaneous conversations with as many as 9 different contacts on their mobile phone. Based on these observations we made several design suggestions for future mobile communication tools. Designing for simultaneous conversations and interoperability between multiple communication channels holds promise to help mobile users manage their many communication threads.

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