DeDe: Design and Evaluation of a Context-Enhanced Mobile Messaging System

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ABSTRACT
This paper presents the design, implementation and validation of an enhanced mobile phone messaging system (DeDe), allowing the sender to define the context in which the message will be delivered to the recipient. A field trial among a socially tight group of teenagers showed that the DeDe feature was incorporated as part of the participants' existing messaging culture. 11,4% of their total messaging output made use of the DeDe feature. The most frequently used context parameters were location (based on network cell-ID) and time. Novel message practices emerged, as compared to 'normal' messaging, both in terms of timing of message sending, as well as creating content that specifically exploited the DeDe feature. Some use barriers were recognized, the most important being the sender's uncertainty of delivery success. Implications for design are discussed.

Author Keywords
Mobile messaging, location-based messaging, field trial, context, mediated communication.

ACM Classification Keywords
C.5.3 Microcomputers; H.4.3 Communications Applications; H.5.2 User Interfaces

INTRODUCTION

Besides linguistics competence, face-to-face conversations require a great deal of social skills, for instance turn taking and adapting to feedback mechanisms. One also needs to determine if a conversational topic is relevant to the given situation, or whether the dialogue should be postponed to a more appropriate time and place. Consider the following examples:

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- Bringing up bad news to a friend ("I will wait until his important examination tomorrow is over.")
- Apologizing to wife for a fight ("It's too noisy in this bar. Need more romantic atmosphere.")
- Discussing work issues when meeting a colleague on Sunday ("He is enjoying his family life. I can talk to him on Monday at office about this")

Assessing the contextual appropriateness of a topic, or 'conversational timing', provides an even greater challenge in mediated communication when conversational partners are not co-located. For instance, phone conversations and mobile messaging typically lack access to the conversational partner's context, making conversational timing difficult, sometimes impossible. Often, the initial stages of the conversation assess the context of the other in order to determine the appropriateness of the topic. For instance, it is typical to start a phone call with questions such as: "Where are you?" or "Do you have a minute?"

One way of solving the problem of lack of access to recipient's context is to build a communication system that allows users to describe their context and share it with other users. On the basis of such information, it is argued, not only conversational timing is easier to assess, but also "conversational availability" [5]. Most commercial IM systems, for instance, augment the contact list by indicating the online presence of each contact, with regard to whether she is 'online', 'offline', or if her computer is in 'idle' state. Knowing the person's habits and preferences, a small marker, such as the login status, can make a big difference to the conversational timing. Most systems also allow a user to write a 'status message' describing their current situation.

Recently, the PC centricity of IM has been addressed by mobile presence systems such as Nokia Presence Solution [6 and Figure 1]. Other extensions of IM systems – both in PC and mobile domains – have added information such as current calendar information [8], current and recent chat activities [2], and to some extent also current location [8].

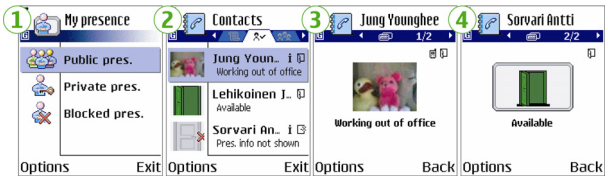

Figure 1. Screenshots of Nokia Presence application and Presence-enhanced Contacts. User-definable Presence information is published in (1). A separate list in the Contacts application shows the status of users subscribed to Presence service (2-4).

All of these systems signify a 'shift of burden' from the conversational instigator to the person being addressed: it is up to the latter to create and make information available about his current context. Although this shift of responsibility clearly increases the possibility of good conversational timing, these systems unavoidably seem to run into a contradiction, as discussed by [3]. On the one hand, the overhead associated with manually updating one's presence status and context information could create a major usage barrier. If, on the other hand, context of the user – e.g., location or calendar data - is automatically detected and published to other potential conversation partners, the system may face privacy problems.

To avoid this dilemma – while still providing support for conversational timing – we turned our attention to a mobile messaging system. Since the mobile phone is typically small enough to be carried close to body all the time, the mobile message notification creates a delicate and implicit expectation between the sender and recipient that the message might be replied to in no time, while not binding the recipient [9]. This way, mobile messaging system crosses a borderline between synchronous and asynchronous communication channels.

Although technology is becoming increasingly pervasive, especially in highly saturated mobile phone markets, this basic concept of mobile messaging has not changed much since its inception in the beginning of the 90's. As IM systems have created a new mode of communication utilizing the availability information of their users, could mobile messaging be enhanced to provide better support for conversational timing and, furthermore, to incur new communication practices?

Concept and Design of the System

The Defined Delivery system (DeDe) was designed to increase the user benefits of asynchronous communication. More specifically, we aimed to create a mobile messaging system with messages being experienced as more relevant to the recipient's context. We hypothesized that DeDe would extend the applicability and utility of mobile messaging as a communication channel, by catering for contextually sensitive message sending and receiving, when the need arises, without privacy concerns.

To avoid the privacy concerns associated with passive sharing – i.e. user's status information shown to others continuously while logged into the system - we decided to take another route, which is in fact more in line with the asynchronous mode of communication: instead of giving the communication initiator access to the context of the other party before sending a message, DeDe system would allow the sender to *define the context in which the message should be delivered*. The DeDe message sending and receiving process can be described in 3 stages:

1. While constructing a mobile message, the sender selects a delivery parameter and then sets a value to that parameter. This defines when the new message notification should reach the recipient. The set parameter value is automatically attached to the message upon sending it.

2. Message is received in the recipient's phone, which registers the parameter value of the DeDe message. Then the phone starts observing the relevant context of the phone for the parameter of the DeDe message (e.g. the current location of the user). The recipient is not aware of the new message, since its notification is 'withheld' and the message is hidden.

3. When the parameter value of the DeDe message matches the context of the phone, the message is delivered to the recipient, i.e., the notification is triggered and the message appears in the default messaging database ('Inbox') accessible by the user. To the recipient, the message notification and the message look more or less like a regular message.

Consider the following use case as an example: The organizer of a picnic wants to remind one of the participants to bring a wine opener. The organizer knows, however, that the recipient is forgetful – a text message reminder sent too early on would not work. The organizer thus decides to send a DeDe message, entering the recipient's home location as the parameter value, as she does not know when the recipient will arrive at home. The recipient's phone will produce a new message notification for this message when she arrives at the defined home location.

Context parameters

DeDe would work in an ideal way if it were possible to select any delivery parameters such that they were relevant to the behavior of the target user. Our intention to run a realistic field trial, however, necessitated the consideration of the following constraints. First, parameters that were feasible with a mobile phone model on the market were preferred. In this way, the burden of participants' learning and risks in implementation would be reduced. Second, the phone

model had to be able to detect such parameters automatically. Third, we wanted DeDe to work without requiring changes in the infrastructure of the mobile network, and be compatible with an existing messaging standard in the GSM network.

Consequently, four delivery parameters were chosen: *Time* would deliver the message to recipient at a defined time; *Location* when recipient's phone is registered to the defined cell of the subscription network; *Phone call* right before the recipient calls or receives a call from a defined number; Finally, *Bluetooth device in range* when recipient's phone detects the defined Bluetooth device (MAC address) nearby.

Implementation of the prototype

The DeDe implementation was built on top of the existing messaging application of the Nokia 7650 handset. In all, by modifying the existing messaging application, test users could still use the normal messaging system, including Short Message Service (SMS) and Multimedia Message Service (MMS), with or without DeDe as a sending option. This was important to us since the field trial aimed at *complementing* the test users' already existing messaging practices rather than *replacing* them. It also intended to minimize the burden of users to learn about a totally new application. In this respect, DeDe differs from other context-aware communication research systems where test users had to adopt a new application, communication practice, and potentially a new device [1 and 7]. The following components were modified or added as new to the existing messaging application:

- DeDe feature was added as a sending option in the MMS editor (Figure 2). MMS allowed us to attach the DeDe specific information to the message itself without compromising message content. Due to the length limitation of 160 characters, DeDe feature was not made available for SMS.

- *New message notification function* was modified in the native phone application so that it would distinguish DeDe messages from 'normal' MMS's and subsequently withhold the notification. For regular messages, notifications would be triggered immediately upon receiving the message.

- Once a DeDe message is received and registered by the system, the *DeDe observer* would track the changing context to discover when the recipient's phone would enter the condition satisfying the given parameter value.

To avoid complexity and to enable effective evaluation of each parameter, users could only choose one context parameter for each message (for problems with Boolean operations on multiple context parameters, see [4]). Also, to alleviate the sender's concern about messages not being delivered at all, the messages were associated with an expiration time. If the condition had not been met by this time, the notification would be triggered independent of the defined delivery condition.

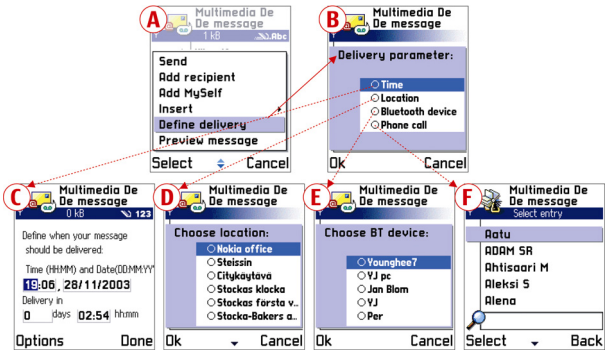

Figure 2. Screenshots from DeDe prototype. A) and B) Choosing a parameter to define the delivery condition. C) Time parameter setup screen. D) and E) Location names and Bluetooth device names are from the DeDe database application. F) Phonebook list from the phone's contacts database.

All four parameters, except time, were defined using numerical values. Use of such parameters required databases on the phone in order for the user to map those numbers to meaningful labels. For phone numbers, DeDe used the phonebook, or contacts database, already existing on the phone (Figure 2F). For location cell-IDs and Bluetooth MAC-addresses, however, we had to create a dedicated database application. This application, called *DeDe database*, allowed users to collect, label, manage and share locations and Bluetooth devices. These labels were then used when setting the parameter value of a DeDe message (see Figure 2D and Figure 2E). To label a location, for instance 'home', users had to open DeDe database while being at the intended location and create a label for it. To encourage learning and use of location and Bluetooth parameters, the researchers equipped the DeDe database of the test phones with 10 popular locations in downtown Helsinki and all the Bluetooth devices of the other participants. DeDe database also allowed sending a labeled location or Bluetooth device over SMS to another user. Users could also 'save' the context parameter value of a received DeDe message if it was new. Note that having the corresponding context parameter value stored in one's DeDe database or the phonebook was *not* a prerequisite for receiving a DeDe message since the parameter values were defined as numerical values, automatically detectable by the phone without the personalized labels.

Assumed user benefits

A number of existing mobile messaging habits identified in an internal (unpublished) pre-study

inspired us to derive the following potential user benefits of DeDe:

- From the sender's perspective, the message can be sent immediately when the idea of writing the message arises. This relates to the reported behaviors of users writing messages in advance and saving them as drafts until an appropriate moment comes to send them.
- From the recipient's point of view, the messages are delivered appropriately to the context, allowing the recipient to react to the messages promptly. This relates to the reported experiences of the users who had to remember to reply to the received message at later time due to the unavailability to reply at the time of reading the message.
- For both messaging parties, DeDe messages could potentially work as an effective social reminder system. This relates to the reported user behaviors that mobile messages were often utilized to confirm or remind certain facts, particularly about upcoming events of common interest.

We also assumed that knowing the message delivery context would intrigue the message sender to create more meaningful and expressive message content.

Research Questions

To investigate acceptance of the DeDe concept, we set up a field trial of the implemented prototype. Preparing for this, the following research questions (RQs) were considered.

1. Will the users adopt the DeDe feature and use it alongside regular mobile messaging?
2. How will DeDe be used in comparison to regular messaging? Will particular use patterns arise, different from regular messaging?
3. Given that DeDe use is characterized using one of four parameters, how will these parameters be used and why?
4. How will users exploit the delaying of the delivery inherent to the DeDe concept? What new messages practices will arise from it?
5. What use barriers does this mode of communication introduce?

The next section sets out the method of the study. Each of the sub-levels of the 'Findings' section provides answers to the individual research questions. RQ1 is addressed through investigation of messaging frequencies. Comparison of the times for sending regular and DeDe messages, and the mutual communication patterns within the group will be highlighted to provide answers to RQ2. The sub-section on parameter use addresses RQ3, whereas qualitative analysis of DeDe message practices will cover RQ4. Finally, RQ5 will be approached in the sub-section 'DeDe use barriers'. The final section discusses general findings, methodological issues and design implications of the study.

METHOD

Participants

To facilitate in-group messaging, and consequently the use of DeDe, a socially tight peer group of seven individuals, comprising of six females and one male, was recruited. Four participants were 17 and three were 18 years old. All of the females (with their fictional names being Tina, Anne, Helen, Eve, Laura, and Sue) attended the same high school in Helsinki and met frequently also during leisure time. The male, Tom, was a more peripheral member of the group but was recruited because he dated Anne.

Participants were all keen users of SMS: each participant reported sending 2-5 messages a day in a pre-screening survey. All were familiar with the general Nokia style mobile phone interface. None of them had used MMS before.

Setup of the test phones

In preparation for the trial, off-the-shelf Nokia 7650 handsets were prepared with DeDe software. In order to allow the user to start using the phone immediately out of the box, the research team installed the DeDe software described above and configured the phones correctly (e.g. the MMS operator settings). The only recognizable changes in the test phones were DeDe enabled MMS editor and DeDe database application.

A logging function was implemented to the test phones, enabling the extraction of accurate messaging activity information. This function tracked both sent and incoming messages, recording information concerning the time of arrival/sending of the message, recipient/sender of the message, as well as the use of the DeDe parameters. The logging functionality was needed as a backup for cases in which the user would delete messages from the Inbox. The log was extracted from each handset after the test period, along with the actual messages of the participants still remaining on the handsets. Altogether 9 mobile phones were prepared with DeDe prototype, one for each of the participants, and two for the research team.

Field Trial

The trial began by inviting the participants to an instruction session, during which the DeDe phones were allocated and instructions given with regard to the use of both the basic phone functions and DeDe, as well as the nature of the trial. The participants were instructed to construct DeDe messages when they would find it appropriate and they were told that the study was about investigating how DeDe would end up

being used. Participants were informed about the logging functionality and that the research team intended to analyse their messages after the trial for research purposes. Participants were generally encouraged not to erase messages, but it was pointed out that if some content turned out to be too private, it was acceptable to do so.

The trial length was 33 days. The researchers communicated with the participants occasionally during the trial period, making sure that DeDe was functioning properly. After the trial period, the participants were interviewed in pairs to discuss the contexts in which they had constructed, sent, and received DeDe messages. The results of these dyad interviews led to the construction of the protocol for a focus group discussion, organized on the following day.

To integrate DeDe as part of the normal, everyday messaging activities, the participants used their personal SIM cards and phone numbers (apart from two individuals who had to change operator for technical reasons). As a consequence, the trial did not disrupt mobile communications outside the group. Similarly to facilitate continuity in mobile communication, participants transferred contents from their personal mobile phones' phonebooks into the test phones during the introduction session. To compensate for higher messaging cost and give reward for participation in the study, all messaging costs during the trial period (both in-group and out-group) were reimbursed.

FINDINGS

Messaging Activity

Table 1 shows the messaging frequencies of the trial period. Column 2 describes SMS activity. Columns 3 and 4 distinguish between 'regular' MMS messages without the DeDe sending option (referred to as 'Normal') and those with DeDe parameters defined (referred to as 'DeDe'). The final column shows the proportion of DeDe messages over total MMS's sent, since the DeDe messages were a subset of MMS's.

As expected, SMS was by far the most common form of messaging, mounting to a total of 460 messages (at the time of the study - October 2003 - MMS subscriptions were quite rare, especially among this age group). 48% of the SMS's (or 219 messages in total) were in-group messages, i.e., messages sent to other study participants, suggesting that the ties among the group members were relatively strong. Average number of SMS messages sent per day, varies between 2.0 (Sue) and 5.2 (Anne).

In total, 274 MMS messages were sent over the course of the trial, out of which 84 were using DeDe feature. On average, this amounts to 0.4 DeDe messages per participant, per day. Considering the limited number of compatible DeDe message recipients, this adoption rate was satisfactory: 11.4% of all sent in-group and out-group messages in the trial were DeDe messages. When looking across the trial period, both MMS and DeDe messaging gradually declined over time. However, normal MMS consistently maintained higher level of usage than DeDe. Overall, to answer our first research question, DeDe use rate is consistent with our original view of DeDe as a feature that complements an existing mobile messaging system, instead of replacing it.

	SMS (in-group)	**MMS*** (in-group)			**DeDe / MMS**
		Normal	DeDe	Total	
Tina	114 (52)	12 (10)	15 (15)	27 (25)	55.6 %
Anne	76 (48)	70 (57)	24 (24)	94 (81)	25.5 %
Helen	50 (13)	18 (11)	20 (20)	38 (31)	52.6 %
Eve	86 (31)	12 (5)	0	12 (5)	0.0 %
Laura	63 (37)	18 (12)	16 (16)	34 (28)	47.1 %
Sue	36 (16)	26 (25)	3 (3)	29 (28)	10.3 %
Tom	35 (22)	34 (25)	6 (6)	40 (31)	15.0 %
Col. total	460 (219)	190 (145)	84 (84)	274 (229)	N/A
Col. Avg.	65.7 (48%)	27.1 (72%)	11.9 (100%)	39.1 (84%)	29.4 %

Table 1. Message sending frequencies across message categories (SMS, MMS and DeDe MMS) and users. The number of in-group messages in each category is shown in brackets. The last column shows the proportion of DeDe messages out of the total number of MMS messages.

Messaging Patterns

One possible way of comparing DeDe patterns to those observed in regular messaging is to look at the time of the day participants engaged in sending the messages. Figure 3 and 4 plot overall message sending frequencies over each hour of the day, in DeDe and regular (both SMS and non-DeDe MMS) in-group messages.

Scale differences aside, sending regular in-group messages slowly increases in the morning, maintaining a steady level between noon and late evening. Between 22:00 and 24:00 there is a clear peak, returning to daytime pace after midnight and then fading out as the night falls. In DeDe the pattern is somewhat different in that two message sending peaks seem to emerge. The peak of the daytime activity takes place between 12:00 and 13:00. This is when the users would have their lunch break at school. As with regular messaging, the all-day peak takes place in the late evening (between 22:00 and 01:00) but it spans a greater number of hours, and is more pronounced. This suggests that the evening hours were important with regard to constructing DeDe messages. We will return to this issue in the 'DeDe Message Practices' section.

Another interesting messaging pattern concerns how participants communicated with each other. When composing a messaging matrix to highlight patterns of communication flow within the group, we discovered

that DeDe was not sent as extensively to all members in the group as compared to regular messaging. On average, the participants sent DeDe messages to 2.8 persons of a total of six possible recipients, as compared to the respective figure of 4.7 in regular messaging. That is, while participants communicated with most members in the group through regular messages, DeDe was sent more selectively, to a fewer number of people. The fact that such selectivity was observed within this relatively tightly knit group of individuals is noteworthy. We believe it can be explained by the fact that sending DeDe requires detailed knowledge of the recipient's future plans, more than normal messaging would do.

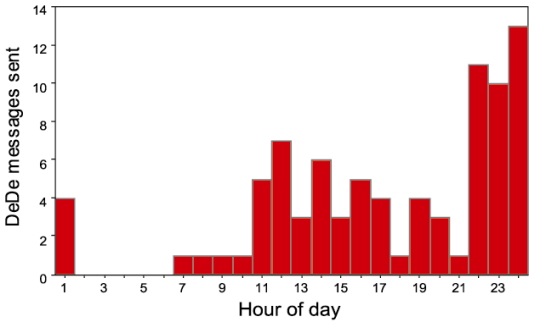

Figure 3. DeDe sending frequencies during the trial among the participants, plotted over each hour of the day.

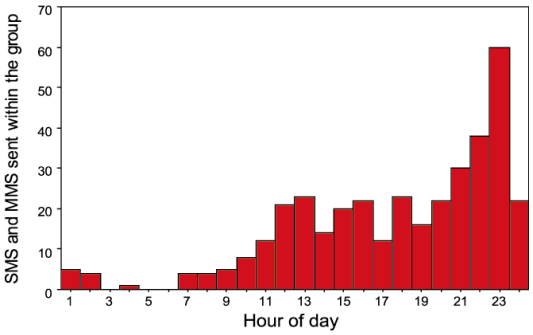

Figure 4. Regular message sending frequencies during the trial, plotted over each hour of day.

Use of DeDe Parameters

Location and time were the most popular parameters - 51% and 41% of all DeDe messages sent, respectively, were of these two types. Bluetooth device and phone call parameters were used in only 6% and 2% of the messages, respectively. The following sections set out detailed descriptions of the use of each of the four parameters.[1]

[1] Location names and message content were created in the native languages of the participants (Swedish and Finnish). They have been translated into English by the authors. Also some of the following example messages contained imagery, but they have been removed for privacy reasons.

Location

In addition to ten pre-configured Helsinki city center locations in the DeDe database application, the participants created a total of 26 location labels, on average 3.3 per participant (some popular cell-IDs received labels from multiple users). Four participants ended up forwarding customized locations to other participants.

Analyzing the location-based DeDe messages and the interviews, the research team identified four categories of locations, explaining how location was used to trigger delivery: *home*, *school*, *passageway*, and *rendezvous*. The table below shows the location labels that were used in the messages, while also illustrating the respective categories and frequencies.

Location label	Category	Messages sent
* Anne's Home	Home	10
* School	School	9
* Helen home	Home	8
Alexander St.	Rendezvous / Passageway	4
Stockmann, inside	Rendezvous	3
* Laura home	Home	2
* School forest path	Passageway	2
* Tina home	Home	1
* Brändö subway station	Passageway	1
Railway station	Passageway	1
Stockmann, outside	Rendezvous	1
* Tom home	Home	1

Table 2. Location parameter values used, including categorizations and frequencies. Location labels created by the participants are marked with '*'. Note that although more than one user labeled some of the locations, only one label per location is shown in the table.

The homes of the participants were popular. In fact more than half of DeDe location-based messages were of such type. Anne acted as the social core of this group and it is consequently not surprising that her home cell was the most popular (10 messages).

The school featured as a trigger of some of the messages. All except Tom attended the same school, making it a hub which most of the individuals visited almost daily. Spending time in the school acted as a 'behavioral invariant' for this group. This was exploited in DeDe messages to minimize uncertainty of delivery. As mentioned in one of the dyad interviews:

"Well, city locations then you cannot be sure what time the others are there. But with school you know fairly well." – Anne

Passageways to and from school were prominent. Some of these were located near the school. 'School forest path' denoted a walk path between school and subway station through which most students arrived to school.

The Brändö subway station itself attracted at least one label. In total 3 messages utilized these locations. Once again, the passageways are illustrative examples of exploiting behavioral invariance. Rather than making DeDe an opportunistic communication mode, the technology was used in a deterministic manner.

Other locations were also clearly treated as passageways to school. Since most of the participants lived in the same district, they all had to pass the city center when commuting to school at Brändö. In this way, many of the preinstalled location labels of downtown Helsinki (e.g. Alexander St., Railway Station, Stockmann inside) in effect turned into passageways to and from school (6 messages). Anticipatory greetings such as DeDe good morning messages were well suited for these locations since it gave the recipient time to read, and possibly reply to messages while sitting on the tram/subway to school (see 'DeDe Message Practices' section).

Fourth, general *rendezvous* locations in downtown Helsinki were used, in which the participants met and socialized after school. Although some of these were saved, only one was effectively used, namely 'Stockmann, inside' (3 messages). Stockmann is a big department store in the heart of Helsinki, with several cafés in which the participants occasionally met up.

The delivery success rate of location-based DeDe messages was surprisingly high. Of 43 location-based messages 36 were actually received at the location intended. Again it shows how predictable the geographical movements within this socially tight group were, and that such invariance was actively used.

Time

41% of sent DeDe messages utilized the time parameter. Just as with locations, participants had maintained good awareness about each other's schedules, both on a day-to-day level and hour-by-hour. This became particularly detailed during school hours, whose minute-exact time slots imposed a temporal grid that was useful for DeDe messaging. Some DeDe messages had quite short delay interval between sending and delivery. In the following message, Helen was still in class when Sue sent the message, but it was set to be delivered when class was over. In this case the delay was only about 16 minutes but still benefited both Sue (get it out of her head and remind Helen to call) and Helen (no disturbance during class). This exact synchronization was enabled by the school schedule.

Sender	Sue	Recipient	Helen
Time of sending		Oct 27, 14:04	
Context parameter: Value		Time: Oct 27, 14:20	
Hi! I called wava, she was to meet her granny, so she can meet us around 4-5. Call me now! Bye.			

Given that time parameter was sometimes used in such an exact fashion, the selective nature of sending DeDe messages becomes understandable. Only individuals who are highly aware of each other's plans, such as good friends of family members, are likely to be able to use DeDe in this precise a fashion.

Bluetooth and phone call

As discussed above, Bluetooth and phone call DeDe messages were used marginally as compared to location and time. One possible reason for this is that configuring these two parameters incorporated triangular relationships. That is, in addition to adding the recipient of the message, the sender would also have to consider an encounter or a phone call with a third party, possibly making the need for such a message delivery rarer and the message more difficult to configure. In addition to the mental load imposed by the configuration of these parameters, the kind of behavioral invariance that was utilized in the case of location based messages was perceived to disappear upon using Bluetooth or Phone call DeDe messages:

Laura: *I mean, how can you know that two persons are about to meet and at what time. Perhaps Bluetooth could be used for quite unimportant and insignificant messages. But I know that Tina passes Alexander Street every day on her way to school.*
Researcher: *But you also knew that you all would encounter each other in school?*
Laura: *But it wasn't certain. You never know.*

Delivery delay time

Overall, the average delays between sending and receiving DeDe messages, for the main parameters location and time, were 9 hours and 3.5 hours, respectively. Two factors are likely to have generated this difference. First, there is an element of uncertainty with regard to when the recipient will enter the selected location, leading to at least some of the messages being delivered relatively late. Second, some of the time-based DeDe messages were sent in a short-term, detailed fashion. For instance, some of these messages were sent during school class, configured to be delivered after class, with a time difference of only a couple of minutes.

DeDe Message Practices

To understand how users exploited DeDe to create novel messaging practices, a content analysis of all DeDe messages was performed. This was complemented with data collected during the interviews. Five practices emerged: *anticipatory greetings*, *contextually sensitive prompts*, *avoiding immediate response*, *joking and teasing*, and *relieving mental load*.

Anticipatory greetings

It was common to compose DeDe messages to provide a 'good morning' or 'have a good day' type of greeting

to the recipient. Seven DeDe messages included the expression 'good morning'. Typically these messages were sent at night, to be delivered at a certain time in the morning or at a location on the way to school. Being unable to send message at early hours was one reason to send anticipatory greetings as DeDe message:

"I knew that Eve would have a competition on Saturday and then I sent a "Good luck with the competition"[on the previous evening][…]. I thought that it's good to get the message going on its way. Because I would surely not be awake at 9 am on a Saturday morning". – Anne

Lying in bed before going to sleep seems to have also constituted a moment of repose and thinking about the next day, suitable for creating a DeDe anticipatory greeting:

"Or when you were at home in the evenings you would send to others, to have a nice school day. In a way…you were in bed and there was time for this."- Helen

This partly also explains the DeDe sending peaks around bedtime (Figure 3 and Figure 4).

In the discussion after the trial, we brought up the issue whether anticipatory greetings can be considered to be impolite or impersonal, e.g. in the example of birthday messages being set months in advance. The participants recognized this risk, but more so with longer time scales than with shorter:

Tom: *But if it was my birthday I would be a bit hurt [if I received a DeDe greeting].*
Researcher: *Would a good morning message be fake then, written on the night before?*
Helen: *Not as much.*
Sue: *I think that would be more ok. If I start [school] at eight, and they start at ten, I know that no one would sit at home at eight and write hi [to me]. So in that sense it's a different thing.*
Tina: *It's recently sent.*

A nocturnal version of an anticipatory greeting was provided by Tom. This message was sent to his girlfriend right after she had left his house at night. The message was defined to be delivered when she would arrive at her home:

Sender	Tom	Recipient	Anne
Time of sending		Oct 17, 22:36	
Context parameter: Value		Location: Anne's home	
Good that you arrived safely at home. No drunkard harassing. Thanks for today…			

In order to avoid confusion, some anticipatory greetings often made explicit reference to the difference between creation time and reception time. The message below sets out an example of such *deictic* referencing (deixis is marked in bold).

Sender	Tom	Recipient	Anne
Time of sending		Oct 11, **01:33**	
Context parameter: Value		Time: Oct 11, **11:00**	
Good morning love. I was first at Bob's, then to Sue's place […] I am thinking of going to Karaoke bar with Micke **tomorrow/today**. **But I go to bed now.** Kiss and hug			

Contextually sensitive prompts

Mobile messages are often used to facilitate the coordination of tasks and planning of activities. DeDe optimized this process by enabling context sensitive prompts with a decreased level of interruptiveness:

Sender	Laura	Recipient	Tina
Time of sending		Oct 16, 17:01	
Context parameter: Value		Location: Tina home	
I have done the homework. Up until 7. Can you go from eight upward so we can then swap answers! They are horrible! Where have you been?			

In the message above, Laura needs Tina to do her part of the homework, but apparently does not know where Tina is at the time of writing the message. She uses Tina's home as the location value, which is likely to be a context in which Tina will be able to do her homework. This is a good example of a context-sensitive DeDe message.

In another example, Sue sent a DeDe message to be received by Helen on her way from school to subway station. She later explained this situation as follows:

"I was thinking maybe she [Helen] doesn't check her mobile immediately after school, but if she receives a message just as she is leaving the school, maybe she checks it out". – Sue

Sue apparently thought that Helen had her hands full inside the school building, but would be more receptive to messages on her way to metro station.

Avoiding immediate response

In some cases, DeDe was used to avoid an unwanted immediate response form the message recipient. Laura, for instance, sent the following DeDe message to Tina one night:

Sender	Laura	Recipient	Tina
Time of sending		Nov 11, 22:25	
Context parameter: Value		Location: Alexander St.	
Is 11.11 fine as a theatre day? The play is interesting and educational. You will not regret! I promiz! Can you "replay" [reply] on this message?			

In the interview Laura explained that Tina was supposed to receive the message on her way to school, when passing Alexander Street. At the time of sending the message, however, she did not have energy to deal

with this matter on the phone (she assumed Tina would call her after receiving this message to talk about the theater issue). Hence she delayed the delivery of the message until the following morning.

Joking and teasing

DeDe messages were sometimes utilized for creating jokes and teasing people. Anne, for instance, reports in the dyad interview about the following practical joke she made at the expense of Sue, exploiting the fact that DeDe messages and regular messages had similar appearance for the recipient:

> *"I had sent [a message] to Sue when she would pass by Stocka [department store] that 'I can see you' or something even though I couldn't. She really got confused and called me."* – Anne

Another example is a message that was aimed at waking up the recipient by configuring the message to be delivered in the middle of the night.

Relieving mental load

Beside the context-sensitive delivery aspects of the messages described above, another clear benefit of the sender provided by DeDe was derived: Once the need for sending a mobile message appeared in sender's mind, she could create and send it and think about it no further. As Anne phrased it: "I thought that it's good to get the message going on its way." This meant that the sender did not have to wait for or keep paying attention to the appropriate timing for sending a particular message content. Provided that the sender knew the habits of the recipient, DeDe alleviated memory workload for the sender while still enabling context sensitive message delivery. In some cases, DeDe enabled sending of messages that would not have been sent otherwise, for instance in the early morning anticipatory greetings. This motivation of 'sending immediacy' was rather general, as it was present in all of above message examples and interview extracts.

Perceived Use Barriers

One of the most salient DeDe use barriers was the low reliability associated with the delivery of the messages. An inherent property of DeDe was that the sender was able to define the delivery condition but not to monitor the outcome of this conditional process due to privacy reasons (delivery reports could, for instance, be used to track users' location or calling behavior). Therefore, when sending DeDe messages the sender could not be certain about the delivery success. This, in turn, had negative implications on usage. Eve, in particular, complained about the unreliability of delivery in the introductory meeting, resulting in her not using the DeDe feature during the trial (see Table 1). The other participants alleviated the uncertainty by a number of different ways. Confirmation requests, such as "please reply to this message if you get this" were sometimes included in the DeDe message body (see e.g. Laura's message to Tina above). The participants would also call each other to find out if the message had been delivered, or take up the issue face to face.

Unfortunately, the network operator's MMS service was also unstable for some days during the trial, potentially causing delayed or even missing messages. This may have contributed to the sense of system 'unreliability' among the test users.

In addition to the reliability issue, lack of saturation of the technology was likely to have limited the adoption of DeDe. After all, DeDe could only be used to communicate with other trial participants, not with the wider network of communication partners. The participants also regarded the trial period as too short to adopt it as part of one's regular messaging ensemble. Finally, some of the technologies used in DeDe, such as Bluetooth and cell-ID, were novel to the users.

DISCUSSION

To sum, DeDe was adopted as part of the messaging repertoire of the participants, accounting for 11.4% of total number of messages sent during the trial period.

Sending DeDe messages seemed to be anchored to moments associated with downtime, namely lunch hour and late evening. This suggests that DeDe feature may be used when most appropriate to the sender, while nevertheless allowing sensitivity in terms of the message being delivered in the desired context.

A range of novel use practices emerged during the trial, centring mainly on the use of location and time parameters. Anticipatory greetings allowed the sender to deliver empathic messages appropriate to the recipient. Defining the delivery context also led to the emergence of e.g. contextually sensitive prompts, which enabled the coordination of mutual activities in a timely manner. These novel practices suggest that features similar to DeDe cater for untapped mobile messaging needs, at least for the type of user group participating in the trial. Certain DeDe usage patterns foreseen by the researchers did not emerge or were not as prominent during the trial. For instance, DeDe was not used as an opportunistic facilitator of chance encounters: "I am in ABC club, drop by if you are passing by!" Such lack of more varied usage patterns could be attributed to the uniform lifestyle of the participants in this study. That is, all of them were high school students and living with parents. Therefore the generalisation of the results across a wider range of user groups is debatable. The findings have to be viewed in a critical sense, while acknowledging the need to conduct studies with other user segments.

While DeDe triggered the sender to think more about the context of delivery when composing a message, it imposed a somewhat higher cognitive workload on the

sender. The sender needed to think about the present as well as the future, such as the recipient's needs and situations at the time or place of reception. This stood in contrast to regular messaging, where the sender only needed to think about the present state of affairs. At the same time, however, it also relieved the sender of the mental load of having to postpone a message sending to a more appropriate timing.

The fact that locations and time were clearly preferred seems to suggest that Bluetooth and phone call parameters were non-useful or too complex to come to the participants' mind when needed. Nevertheless, lack of Bluetooth devices and the frequent face-to-face meetings within the group, could also have reduced the utility of Bluetooth and phone call enabled DeDe messages. Had another kind of group been chosen (family, work colleagues), the results might have been different.

Methodological issues aside, the frequent use and storage of behaviourally invariant locations suggest that the awareness of habits and routines of the communication partners may be required to make most use of DeDe. Consistent with this, DeDe messages were sent to a fewer number of recipients as compared to non-DeDe in-group messages. Such awareness may also be relevant in other messaging modes, but we believe it is particularly prominent in the case of DeDe.

Design Implications and Future Research

A number of issues concerning the interaction design and the basic social principle employed by the system were brought up in the study.

First, the need of delivery confirmation report was debated. A compromise, that would strike a balance between delivery reliability and privacy concerns would be to prompt the recipient after reading the message whether or not a delivery report should be sent.

Second, a possibility to easily check the sent DeDe messages was raised by a couple of users. Due to the delay in the delivery, the message sender may forget about the message content written a few days ago or need to change the content of the message before it is delivered. A separate list of sent DeDe message would support the user to quickly review the sent messages and possibly provide a way to update the sent message with new content, particularly if this list were to be combined with the aforementioned delivery report system.

Future implementations of DeDe should also focus on finding other suitable context parameters for any given user group while reducing the complexity of the context definition process. Furthermore, collecting, managing and sharing customized context labels should be optimised in the DeDe database. Especially, the sharing of labelled context, e.g. locations, should be easy and cost effective in order to achieve the wider adoption.

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