

Exploring the importance of context parameters for service use in everyday situations

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The work described herein focus on the impact of different context factors in short-term planning situations. We have investigated which services have been used to solve different tasks. The method used in the study was based on scenario descriptions. The participants reported how they would have acted in different situations and they also rated the importance of different context factors in different situations. Analyses were made that revealed relationships between context factors and services used by the participants of the study. A qualitative analysis was also conducted, with the aim to capture context factors not covered in the study design.

1 Introduction

This report describes the methodology, results, and analyses of the second phase of a two phase study. The purpose of the first phase was to draw a map over context-aware computing in uncontrolled settings, identifying potentially useful context factors and domains of interest on a high level. The purpose with the second phase (described herein) has been to address three goals (listed in priority).

1. Provide data that can assist in sorting services by relevance based on user context. This information is intended to be used to arrange icons (representing services) on a desktop, and suggesting services pro-actively.
2. Provide data that reveals dependencies between different services (and possibly devices). This information is intended to be used to assist users in service (and possibly device) integration.
3. Describe “nice and clean” usage scenarios.

The first and third goals are addressed directly in this report (primarily in section 3.2 and 3.1). The second goal is addressed by the study, but no analysis of the data is provided in this report.

1.1 Domain

The domain of the study was restricted to short-term planning and ad-hoc planning. In the pre-study phase different context factors related to the use of services in mobile and uncontrolled settings were observed. Several context factors that were interesting and worthwhile investing further were noted, and a number of different domains were identified. Short-time planning was one domain which seemed to play an important role, in which the need to use and to combine different services and activities was crucial. Based on these findings, the second part of the project and its second phase focused on short-term planning, and in some situations, how it extended into ad-hoc planning.

Short-term planning takes place during the same day as, but well before, a planned activity. In numerous cases, participants in the pre-study phase planned lunch activities for the same day during the early work hours (while working in their office), or evening activities during the afternoon. Many work meetings (between participants within the same company) were also planned in this way. This kind of planning involved several different

communication artifacts and information sources including paper calendars, cell phones (SMS, phone book, calendar, voice calls), and personal computers (calendar, email, phone book, and instant messaging) – often in various combinations.

Ad-hoc planning takes place on the way to an activity. The ad-hoc planning observed in the first study occurred in some situations at work; however, it was more common before or after work. People made calls on their cell phones and sent instant messages (e.g. SMS and ICQ) just before they left a place for activities elsewhere, or while they were on the way to an activity. In some cases participants in the study even invited peers to activities while they were on the way to the same.

1.2 Approach

We acknowledge that the term context in computer science is poorly defined, mostly because it is difficult to limit the meaning of the term while still making it general enough to apply to many uses in context-aware computing (Dey, Abowd & Salber 2001).

In the following, we adopt the use of the term context by Terry Winograd in which it is referred to as an operational rather than a descriptive term.

...something is context because of the way it is used in interpretation, not due to its inherent properties. (Winograd 2001).

Winograd further describes how the term can be applied.

Context-aware computing might be better described as the design of computing mechanisms that can use characterizations of some standard aspects of the user's setting as a context for interaction. (Winograd 2001).

In the settings that the participants encountered in this study there were many factors that could contribute to the context for interaction with computing mechanisms, many of which we take for granted. Some are implicit or impossible to measure or quantify objectively (Dourish 2004; Grenberg 2001). This study however, aims at exploring this space of potential context factors. It also suggests correlations between factors that can be quantified at some level and uses of different services. In an effort to extend the use of the results from this study beyond the set of services that are included, we search for correlations between context factors and general properties of services rather than the specific services. In order to do this we categorize each service in a number of dimensions (see 2.2 for a further description).

2 Method

The method used was based on scenarios and scenario descriptions. The development of scenarios was also a goal in itself for this study, where the scenarios could serve as descriptions of typical situations where people use mobile services in short-term planning activities. Scenarios are short stories or descriptions that serve as a means to make different situations vivid for the participants. It is a commonly used method within the field of Human Computer Interaction (Kuutti, 1995), and it has also been used within the domain of use and need for mobile services and devices (Iacucci & Kuutti, 2002).

2.1 Development of scenarios and questionnaire

Based on the observations in the pre-study phase, scenarios related to short-term planning were developed. The use of the collected materials from these observations provided rich contextual descriptions and contributed to scenario descriptions with high ecological validity. However, to suit the demands of the quantitative study the scenario descriptions had to be developed further. The purpose was to create scenarios that most participants (see section 2.4)

could relate to. Further, it was important to create simple scenarios to minimize errors related to the experimental situation.

All situations related to short-term planning and ad-hoc planning covered in the pre-study phase were compiled. Based on the different situations identified, several general scenario descriptions were written. In these descriptions all details related to each particular situation were removed, and only a rough skeleton of a scenario remained.

After that, the scenarios were tested with participants in a pilot study, in which the participants were interviewed about the scenarios. The material from the interviews was used to enrich the scenarios with details that would make the situations vivid and close to real life situation. However, only details that many participants related to in the interviews were used.

All scenario descriptions were categorized in five dimensions of context factors identified in the pre-study phase.

Disturbance – The level of which the subject may disturb surrounding activities.

Urgency – The urgency with which the subject need to solve the task.

Sound level – The surrounding sound level.

Privacy – The degree of privacy of the subject while solving the task.

Attention – The degree of focus that the subject can place on solving the task.

Each scenario was described in terms of these context factors, with each factor set according to a three-grade scale (low, medium, and high). A questionnaire with questions related to how the participants would act, using which services, given the scenarios, was developed. It also included questions about which context factors had contributed to choosing that particular solution. On a scale ranging from 1 to 5 the participants ranked how important different context factors had been in their choice of services. However, based on the findings from pilot tests, the ranking was made together with the experimental leader since we wanted the participants to thoroughly identify with the situation and consider each individual context factor properly. The overall goal with this was to achieve better understanding of the questions, more serious answers to the questions, and as a consequence reaching a higher validity.

2.2 Services and service parameters

During the study sessions, the services were represented on cards, with one service on each card. The representation consisted of a short text (a name) and a picture. On the back of the card, a more detailed description of the service was provided. The services used in the study along with their detailed descriptions are listed below.

Address book – Look up or write down contact information in an address book, e.g. a paper calendar, cell phone, computer, or PDA.

Alarm – Set a reminder on e.g. a cell phone, computer, PDA, or an ordinary alarm clock.

Your position – Find out where you are. You can do this with e.g. your cell phone, a computer, a PDA, or an ordinary map.

Email – Send or read an email from e.g. a computer, a PDA, or a cell phone.

Fax – Send or receive a fax via e.g. a fax, a computer, or a cell phone.

Friend finder – Get the position of someone you know. You can do that with e.g. a cell phone, a computer, or a PDA.

Information search – Search for information such as e.g. places to eat or shop. The search can be done via the Internet, a phone, or in a number of other ways.

Calendar – Look up or make a note in a calendar. The note can be done in e.g. a paper calendar, on the cell phone, or on a computer.

Camera – Take a photo with e.g. a cell phone or a digital camera.

Watch – Check the time on your ordinary watch, the cell phone, or by asking someone.

MMS – Send or read a MMS in e.g. a cell phone or on a computer.

Cell phone – Place or receive a phone call on a cell phone.

SMS – Send or read a message from e.g. your cell phone.

Instant messenger – Send or read an instant message (ICQ, Yahoo or MS messenger) on e.g. a computer, a PDA, or a cell phone.

Games – Play a game on e.g. a cell phone, a computer, or a PDA.

Telephone – Place or receive a phone call on an ordinary telephone.

Video call – Place or receive a video call on e.g. a 3G-phone, a computer, or a PDA.

The participants were also free to suggest other services than the above listed and they could also make up non-existing services or solve the situation without the use of any service at all.

In an attempt to provide more general results that extends beyond the services that users could choose from (or suggest by themselves), we categorized each service by a number of service properties (see Appendix I for the complete categorization). The aim is to capture more of the intent behind using a service rather than identifying the service itself. Three categories were identified.

Type – The services used in the study were identified as belonging to one of 5 types: communication, information, entertainment, planning, or Geographic Information Systems (GIS).

Modality – Each service were categorized by their primary modality (or modalities): picture, voice, text, and video. Some services support several modalities (e.g. MMS that support picture, voice, and text). It is important to note that we have only selected the primary modalities. For example, in our categorization email supports text only despite the fact that pictures, voice messages, and video clips can be attached to an email.

Requirements – A number of requirements that services can place on a setting constitute the third category: hearing, vision, dexterity, cost per use for the user, mobility, and usage sounds. Dexterity refers to a required skill and ease in using the hands throughout service use. In this case cell phone is not considered since it mostly requires its user to hold the phone to the ear, while SMS is considered to require dexterity since typing an SMS message requires focus and active use of at least one hand. Cost per use for the user is a coarse estimation since cell phones, SMS, and MMS are considered; the use of some of the participants' cell phones was paid by their employers.

In addition, services that belong to information and communication are further categorized.

Communication type – Each communication service is categorized as being either synchronous or asynchronous, as well as supporting multi-party communication or not.

Information search type – The information search services or actions are divided into different groups depending on the information source: the Internet, signs, printed material, or through social interaction. Social interaction can take place with official persons (e.g. movie theatre staff and bus driver), known person (e.g. friends and colleagues), or unknown persons (e.g. a person on the street).

2.3 Experimental procedure

After an introductory scenario where the leader exemplified planning activities and typical think aloud answers to the introductory scenario, the participants were asked to conduct short-term planning activities, based on six scenarios. The scenario descriptions were first read aloud by the experimental leader after which the participants were instructed to read them for themselves once more. After each scenario, the participants were asked to choose a subset of services from a large set of both existing and fictive services. Their task was to choose services that they would use to solve the situation presented in the scenario.

The participants were then asked to “think aloud” during their selection of services. They were asked to describe how and when they would use the different services that they had selected. After each scenario, the participants also answered the questions related to that specific scenario and its context factors. Questions were also asked about how easy it was to identify with each scenario. The entire session was recorded on an audio device.

2.4 Participants

In the study there were 41 participants between 20 and 45 years of age (age: $m=27.88$). There were 16 men (age: $m=27.87$) and 25 women (age: $m=27.88$). One fourth of the participants were living on their own (26.8%), two thirds were living together with someone (63.4%), and about 10% were still living with their parents (9.8%). These figures were quite similar for men and for women, see Table 1.

	All participants	Men (n=16)	Women (n=25)
Age (average)	27.88 (SD 6.31)	27.87 (SD 6.27)	27.88 (SD 6.46)
Cohabitant status (frequency)	Single	11 (26.8%)	4 (25%)
	Cohabitant or married	26 (63.4%)	10 (62.5%)
	With parents	4 (9.8%)	2 (12.5%)
University education (frequency)	38 (93%)	15 (94%)	23 (92%)
Children (frequency)	13 (31.7%)	6 (37.5%)	7 (28%)

Table 1. Background variables regarding the participants.

The participants were recruited through bulletin boards at different places (office buildings, at the university etc.). The participants were selected in the same way as in the pre-study phase and the aim was to find people similar to the ones that had participated in this phase. This was important since we had to find people who had the same background and life style and therefore could relate to and recognize themselves in the situations described in the scenarios.

3 Results

This section starts with results related to each specific scenario. These results are followed by analyses that are based on all scenarios, and related to the different context factors and the use of different services. Finally, a qualitative analysis, based on the results from the “think aloud” materials, is presented.

3.1 Analysis of scenarios

The participants were given six scenarios. They are presented below, together with their context factors and the results related to each specific scenario.

First, frequencies of services used in each scenario are presented, together with frequencies of properties related to the services used in the study. How the participants used the services, and to what subtasks they used different services, is also discussed.

The participant-rated importance of different context factors is presented for all participants together, as well as for men and women separately. One-way analyses of variance were used to examine gender differences regarding rated importance of context factors. Further, correlations between the different context factors within each scenario were calculated (using Pearson’s correlation coefficient). These analyses were made to investigate to what extent the importance of different context factors interplayed with each other. Age was included in all analyses to examine correlations between age and the rated importance of different context factors. Only correlations where the context factors were either high or low were investigated, and only correlations significant at the 0.01-level was considered because

of the risk of reaching significant results by chance in a situation where many comparisons were made.

Finally, new services and factors that the participants suggested or discussed are presented. These factors are described in an explorative and qualitative manner since they came up during the study. They are not investigated with respect to all participants since they were not included in the study design.

3.1.1 Scenario 1

The first scenario was trying to capture a lunch planning situation, where the organizer of a lunch meeting is walking in the street in a noisy environment. There is a limited amount of time to arrange the lunch meeting, and there is also a limited amount of time to spend on the actual lunch meeting.

It is just before lunch and you are walking in the street on your way from a meeting when you realize that you have forgotten to bring lunch with you. Even though you have to hurry to another meeting after lunch you feel like having lunch with a friend who works in a nearby office.

3.1.1.1 Service use

A cell phone was the most common device used for solving the task in scenario 1. Several of the participants also searched for information, looked in an address book, and checked the time on a watch, see Table 2. The address book (in the cell phone) was mainly used for looking up the phone number to the friend shortly before calling, and the information search was about finding restaurants etc. Most communication was synchronous, something that seemed to be important in situations where a task has to be solved in a limited amount of time.

Services (frequency of use)		Categories (frequency of use)	
Address book	5	Communication	38
Alarm	1	Information	18
Your position	2	Entertainment	0
Email	0	Planning	1
Fax	0	GIS	5
Friend finder	3	Synchronous	38
Information search	6	Asynchronous	1
Calendar	2	Multi-party	0
Camera	0	Internet	5
Watch	7	Signs	0
MMS	0	Printed material	0
Cell phone	38	Social interaction (official person)	1
SMS	1	Social interaction (known person)	0
Instant message	0	Social interaction (unknown person)	0
Games	0	Picture	5
Phone	0	Voice	38
Video chat	0	Text	18
No aid/tool	2	Video	0
		Hearing	38
		Vision	18
		Dexterity	1
		Cost per use for the user	38
		Mobile	39
		Usage sounds	38
		Stationary/Mobile setting	Mobile

Table 2. Services and service properties in scenario 1.

3.1.1.2 Importance of different context factors

In this scenario the limited amount of time was the most important factor in the selection of devices and services, all other situational aspects were rated as non-important by the participants, see Table 3. There were no significant gender differences regarding the rated importance of the different context factors, however women rated the importance of the sound level higher than the men. No significant correlations were found, neither between the context factors with high respectively low value, nor with age. However, there was a tendency towards a significant correlation between high urgency and low privacy ($r=-.38$, $p=.014$). This might indicate that if high urgency is considered to be important, the importance of, or the demands on, privacy decreases and this context factor is considered as less important.

Context factors	All participants (SD)	Men (SD)	Women (SD)	Sign ($p<.05$)
Disturbance Medium	1.10 (.30)	1.12 (.34)	1.08 (.28)	N.S
Urgency High	4.27 (.95)	4.19 (.91)	4.32 (.99)	N.S
Sound level Medium	1.32 (.85)	1.00 (.00)	1.52 (1.04)	N.S
Privacy Low	1.07 (.47)	1.00 (.00)	1.12 (.60)	N.S
Attention Low	1.80 (1.31)	1.62 (1.15)	1.92 (1.41)	N.S

Table 3. Perceived importance of the context factors in scenario 1.

3.1.1.3 New services

No new services were proposed for scenario 1. One possible explanation to this is that this scenario was simple (not that complex) and therefore the need of a wide variety of solutions was limited. Another possible explanation is that the participants were more cautious and less creative in the beginning of the test than later on¹.

3.1.1.4 New factors

New factors were added by the participants, but most of them by only one or two participants (e.g. a need for a quick reply or a need to relax during lunch). However, six participants² mentioned that the importance of the friend (how much do I want to eat with the friend?), the lunch (how hungry am I?) and the meeting (how important is the meeting?) affected how they responded to the situation. If one of them was more important than the other the participants considered to skip the less important.

3.1.2 Scenario 2

Scenario 2 consists of a planning situation where the organizer is making the final arrangements for an evening meeting with a friend. He/she is still at the office having some work related tasks to finish. The environment is quiet, since all the colleagues have left the office.

The day is getting late and you are the only one left at the office. You need to finish some work before you leave, and you feel somewhat stressed because you have made plans for the evening with a friend. You have agreed to get together somewhere downtown, but nothing further is planned so far. In order to get downtown you need to take a bus, which you rarely do.

3.1.2.1 Service use

The most used services in this scenario were information search and the use of a landline phone. Some of the participants also used a watch (see Table 4). The information seeking part of the task was conducted from desktop/notebook computers over the Internet (e.g. a bus

¹ One participant (a14) said he would be more creative if he would do the test one more time.

² a03, a05, a19, a24, m02, b01

timetable). Several of the participants reported that they felt comfortable with performing this private task at the office, since there were no other people left at the office. The part of the task that consisted of deciding place and time for the meeting with the friend was characterized by the use of synchronous communication.

Services (frequency of use)		Categories (frequency of use)	
Address book	6	Communication	41
Alarm	3	Information	36
Your position	1	Entertainment	0
Email	3	Planning	3
Fax	0	GIS	2
Friend finder	1	Synchronous	32
Information search	36	Asynchronous	15
Calendar	0	Multi-party	3
Camera	0	Internet	33
Watch	11	Signs	0
MMS	0	Printed material	4
Cell phone	3	Social interaction (official person)	0
SMS	8	Social interaction (known person)	0
Instant message	5	Social interaction (unknown person)	0
Games	0	Picture	2
Phone	30	Voice	32
Video chat	0	Text	26
No aid/tool	0	Video	0
		Hearing	33
		Vision	26
		Dexterity	15
		Cost per use for the user	10
		Mobile	22
		Usage sounds	33
		Stationary/Mobile setting	Stationary

Table 4. Services and service properties in scenario 2.

3.1.2.2 Importance of different context factors

In scenario 2 the limited amount of time also seemed to be the most important context factor, however it was closely followed by the amount of attention that the participant was able to give the task, and by the importance of being private. There were no significant gender differences in the ratings of the importance of the context factors. However, the largest gender difference were found regarding being able to be private, where women rated privacy to be more important (see Table 5). Further, there was a significant correlation between the rated importance of high privacy and the importance of actually not being forced to show consideration to colleagues ($r=.44$, $p=.005$). No significant correlations between the rated importance of the context factors and age were found for this scenario.

Context factors	All participants (SD)	Men (SD)	Women (SD)	Sign ($p<.05$)
Disturbance Low	1.68 (1.06)	1.44 (.81)	1.84 (1.18)	N.S.
Urgency High	2.95 (1.58)	2.75 (1.53)	3.08 (1.63)	N.S.
Sound level Low	1.07 (.26)	1.12 (.34)	1.04 (.20)	N.S.
Privacy High	2.05 (1.28)	1.56 (.81)	2.36 (1.43)	N.S.
Attention High	2.32 (1.52)	2.25 (1.44)	2.36 (1.60)	N.S.

Table 5. Perceived importance of the context factors in scenario 2.

3.1.2.3 New services

No new services were proposed.

3.1.2.4 New factors

A total of ten new context factors were listed by the participants, of which three were mentioned by more than a few: the cost of using a service, the friend's access and use of services, and the importance of their friends compared to their work. A total of 14 participants³ mentioned that the cost of using a service (compared to an alternative) affected how they responded to the scenario. They preferred to use a cheaper alternative compared to a more expensive one.

The friend's access and use of services was listed as a factor by eight participants⁴. Participants that listed this factor determined which services to use based on for example how often their friend checked email or whether they read SMS messages or not.

Just as in scenario 1, the importance of going out with ones friend compared to finishing work was listed as a factor by a number of participants⁵. Two of them⁶ stated that if the work was not that important they would probably try to finish it some other day.

3.1.3 Scenario 3

In scenario 3, the planning was again related to leisure activities later on in the evening. In this situation however, the planning of the activities are more of spare time activity that was conducted when the organizer had little to do at work. The environment in the scenario was an open office environment with many people and colleagues nearby. In the scenario the person conducting the planning task was confronted with the issues of having time to perform private tasks at work, but on the other hand having little privacy and with the risk of disturbing colleagues.

You are at work shortly before lunch. You work in an open office environment which means that some of your colleagues, including your boss that is close to your desk, can hear and see what you do. There is a lot of noise and commotion around you today but you don't have that much to do. You feel like doing something fun with your friends tonight and you remember that a downtown movie theater is showing a movie that you would like to see.

3.1.3.1 Services use

The most common used services in solving the task in scenario 3 were email and searching for information. The use of a stationary phone and sending SMS were also quite frequent (see Table 6). The information searched for was movie information: which movie to see, where, and when. Beside the use of the stationary phone, the communication was mainly asynchronous and based on the use of text instead of voice. One interpretation of this is that the large amount of time that could be spent made it possible to use more time consuming ways to communicate. It was also plenty of time left before the actual activity should take place, something that made it possible to send text messages and wait for the answer. The selection of services can also be explained by its discrete characteristics.

³ a03, a08, a09, a12, a14, a16, a17, a18, a19, a20, a21, a23, a24, s02

⁴ a05, a06, a07, a12, a22, a24, m07, s05

⁵ a05, a11, a14, a21, m07, b01

⁶ a11, a14

Services (frequency of use)		Categories (frequency of use)	
Address book	7	Communication	41
Alarm	1	Information	23
Your position	0	Entertainment	1
Email	24	Planning	1
Fax	0	GIS	1
Friend finder	1	Synchronous	17
Information search	23	Asynchronous	37
Calendar	3	Multi-party	24
Camera	0	Internet	23
Watch	3	Signs	0
MMS	1	Printed material	0
Cell phone	5	Social interaction (official person)	0
SMS	13	Social interaction (known person)	1
Instant message	7	Social interaction (unknown person)	0
Games	1	Picture	3
Phone	12	Voice	10
Video chat	0	Text	38
No aid/tool	0	Video	0
		Hearing	18
		Vision	38
		Dexterity	37
		Cost per use for the user	19
		Mobile	26
		Usage sounds	8
		Stationary/Mobile setting	Stationary

Table 6. Services and service properties in scenario 3.

3.1.3.2 The importance of different context factors

The context factors that were rated to be most important were absence of privacy and being able to spend time (see Table 7). There were no significant gender differences regarding any of the rated importance of context factors. Further, there were no significant correlations between the ratings of the different context factors with high respectively low value, nor between these ratings and age.

Context factors	All participants (SD)	Men (SD)	Women (SD)	Sign (p<.05)
Disturbance High	2.83 (1.70)	2.56 (1.59)	3.00 (1.78)	N.S.
Urgency Low	3.66 (1.41)	3.75 (1.44)	3.60 (1.41)	N.S.
Sound level Medium	1.29 (.68)	1.31 (.70)	1.28 (.68)	N.S.
Privacy Low	3.95 (1.40)	3.94 (1.44)	3.96 (1.40)	N.S.
Attention High	2.63 (1.43)	3.06 (1.39)	2.36 (1.41)	N.S.

Table 7. Perceived importance of the context factors in scenario 3.

3.1.3.3 New services

A few new services were added by the participants in the third scenario. The most common service, listed by seven participants⁷, was Internet-based ticket reservation. This is an existing service that many participants seemed familiar with. Multi-party communication from a cell phone was also listed⁸, and another participant⁹ delegated the task of buying movie tickets to a friend.

⁷ a03, a22, a23, m02, m05, m06, m07

⁸ a24

⁹ a13

3.1.3.4 New factors

As in scenario 2, the cost of using services was listed by some participants¹⁰. Another group of participants¹¹ found it important not to spend a lot of time on solving the task outlined in the scenario. By this they meant the total amount of time spent on solving the task, and not how long it took before the task was completed. As in scenario 2, the friend's access and use of services was listed by eleven participants¹².

3.1.4 Scenario 4

Scenario 4 concerned planning when several people were involved. The task to be solved in the scenario included coordination of all the people in a group and also coordination when the original plan failed. Being on the move (not sitting in front of a desk) and being under time pressure was also included in the scenario.

You and three friends have agreed to see "Gone with the wind" at the Orion movie theater at 9 PM. You should be at the theater in time to buy tickets, while your friends will arrive shortly before the movie begins.

While you are standing in the crowded movie theater 45 minutes before the movie begins you realize that the movie that you have decided to watch has sold out.

3.1.4.1 Service use

In scenario 4 the most selected services were information search and calling on a cell phone (see Table 8). The purpose of the most frequently used service, information search, was to find other movie alternatives by looking at information boards in the movie theatre. It seemed like the situation demanded synchronous communication to a great extent since there was little time left to make decisions. There were also limited opportunities to use other devices than a cell phone.

¹⁰ a02, a03, a09, a20

¹¹ a08, a14, a18, m02, b03

¹² a02, a03, a05, a06, a12, a15, a16, a18, a23, b02, b04

Services (frequency of use)		Categories (frequency of use)	
Address book	8	Communication	38
Alarm	0	Information	18
Your position	1	Entertainment	0
Email	0	Planning	1
Fax	0	GIS	5
Friend finder	3	Synchronous	38
Information search	21	Asynchronous	1
Calendar	0	Multi-party	0
Camera	0	Internet	2
Watch	3	Signs	15
MMS	0	Printed material	0
Cell phone	34	Social interaction (official person)	4
SMS	2	Social interaction (known person)	0
Instant message	0	Social interaction (unknown person)	0
Games	1	Picture	5
Phone	0	Voice	34
Video chat	0	Text	18
No aid/tool	3	Video	0
		Hearing	34
		Vision	18
		Dexterity	1
		Cost per use for the user	38
		Mobile	39
		Usage sounds	37
		Stationary/Mobile setting	Mobile

Table 8. Services and service properties in scenario 4.

3.1.4.2 Importance of different context factors

In this situation the participants rated being in a hurry (high urgency) as the most important context factor, all other context factors were rated as quite unimportant. Men rated the importance of being in a hurry higher than the women in the study. However, this gender difference was not significant (see Table 9). No significant correlation between the ratings of the context factors with high respectively low value were found, nor between the ratings of the context factors and age.

Context factors	All participants (SD)	Men (SD)	Women (SD)	Sign (p<.05)
Disturbance Medium	1.05 (.31)	1.00 (.00)	1.08 (.40)	N.S.
Urgency High	3.90 (1.53)	4.44 (1.21)	3.56 (1.64)	N.S.
Sound level High	1.71 (1.35)	1.62 (1.26)	1.76 (1.44)	N.S.
Privacy Medium	1.10 (.30)	1.06 (.25)	1.12 (.33)	N.S.
Attention High	1.88 (1.42)	2.00 (1.55)	1.80 (1.35)	N.S.

Table 9. Perceived importance of the context factors in scenario 4.

3.1.4.3 New services

Four participants¹³ felt a need for multi-party communication when renegotiating what to do after realizing that the movie that they wanted to see had sold out.

3.1.4.4 New factors

As many as 17 participants¹⁴ found it important to show their friends respect in the decision-making process. As a result they did not want to make a decision all by themselves that the friends would not agree to. One participant¹⁵ expressed that she would rather wait for her friends to come than to decide what to do by herself.

¹³ a07, a14, a24, b04

¹⁴ a01, a05, a07, a08, a10, a11, a13, a14, a16, a17, a18, a19, a20, a23, m06, s01, s05

¹⁵ a14

3.1.5 Scenario 5

In this scenario the participant were confronted with a situation that took place on a bus on the way to a friend. Suddenly the person in the situation realizes that he/she has forgotten the note where the friend's address is written. There was a limited amount of time to solve the task in the situation since the bus stop might be around the corner. The environment in this situation was quite calm; however there were some noise related to the bus and the traffic.

You have just entered the bus on your way to a friend that recently moved. You find an unoccupied seat quickly because there are few people on the bus. You search for your note where you have written down the friend's address, the bus stop, and the instructions of how to go from the bus stop. Unfortunately it turns out you have forgotten the note at home.

3.1.5.1 Service use

Regarding scenario 5 the most commonly selected services were information search and cell phone (see Table 10). The communication was synchronous and direct voice communication was used instead of communicating using text. This way of communicate might be related to the limited access to different devices (sitting on the bus) in combination with urgency.

Services (frequency of use)		Categories (frequency of use)	
Address book	8	Communication	38
Alarm	0	Information	13
Your position	2	Entertainment	1
Email	0	Planning	0
Fax	0	GIS	4
Friend finder	3	Synchronous	37
Information search	19	Asynchronous	4
Calendar	1	Multi-party	0
Camera	0	Internet	6
Watch	2	Signs	3
MMS	0	Printed material	0
Cell phone	37	Social interaction (official person)	8
SMS	3	Social interaction (known person)	1
Instant message	1	Social interaction (unknown person)	3
Games	1	Picture	5
Phone	0	Voice	37
Video chat	0	Text	16
No aid/tool	1	Video	0
		Hearing	37
		Vision	16
		Dexterity	4
		Cost per use for the user	38
		Mobile	40
		Usage sounds	35
		Stationary/Mobile setting	Mobile

Table 10. Services and service properties in scenario 5.

3.1.5.2 Importance of different context factors

The context factor that was rated to be most important was being in a hurry (see Table 11), not surprisingly since it was urgent to get this information as soon as possible (sitting on a bus and not knowing where and when to get off). The ratings of privacy and disturbance were rather low. It might be explained by that the participants seemed to think that the topic of the conversation (getting information about the address etc.) was non-personal and therefore they did not feel uncomfortable with talking in an environment with low privacy. There were no significant gender differences between the rated importance of the context factors, and no

significant correlation between the factors with high respectively low value, nor between these factors and age.

Context factors	All participants (SD)	Men (SD)	Women (SD)	Sign (p<.05)
Disturbance Medium	1.46 (1.14)	1.31 (1.01)	1.56 (1.23)	N.S.
Urgency High	3.39 (1.69)	2.94 (1.69)	3.68 (1.65)	N.S.
Sound level Medium	1.12 (.46)	1.00 (.00)	1.20 (.58)	N.S.
Privacy Medium	1.54 (1.14)	1.25 (.57)	1.72 (1.37)	N.S.
Attention High	2.05 (1.48)	1.73 (1.44)	2.24 (1.51)	N.S.

Table 11. Perceived importance of the context factors in scenario 5.

3.1.5.3 New services

This scenario triggered the most suggestions for new services of all six scenarios. Seven participants¹⁶ expressed a need to take notes while receiving information/instructions in a phone call conversation. Three participants¹⁷ asked for a map at the bus stop, from which they would be able to find their way to their friend. One participant¹⁸ expressed a need for a navigator. He assumed that the navigator would give him information about where to get off the bus and how to find his way from the bus stop (given that he provided the correct address).

3.1.5.4 New factors

A number of new factors were listed by a few participants such as cost, the coverage of the cell phone network, the colleague's access to and use of technology, and whether the bus ride was bumpy or not (SMS preferred to paper and pen notes during bumpy ride). Twelve participants¹⁹ felt that the nature of some information treated while addressing the scenario was such that it determined how they acted. For example, one participant²⁰ found it easier to navigate by map (found on the Internet) rather than by instructions given to her over a cell phone.

3.1.6 Scenario 6

Scenario 6 describes a situation where new plans have to be made. The planning activities concerns deciding where to go for the evening, as the place of the scenario is too crowded and noisy. The social setting is a group of friends. There is no hurry nor any coordination of people since they have no plans to meet any other friends.

You and your friends are temporarily in a city that you have never visited before. A colleague that has lived in the city has recommended a nice pub and you decide to go there. When you arrive it turns out it that it has a lively atmosphere and that the music is bad. You don't feel like staying there and you would rather move on to a better and a quieter place.

3.1.6.1 Service use

The most commonly used service in scenario 6 was information search. The cell phone was also used by some participants. However, several participants did not use any services at all (see Table 12). The information search was mainly represented by social interaction with unknown people (asking other guests in the pub, in the street, or a taxi driver). Besides the need to get information, the properties of the services used were related to synchronous communication. The environment in the scenario did not make the participants feel that they

¹⁶ a05, a12, a13, a14, a19, m04, s03

¹⁷ a04, m03, m04

¹⁸ b04

¹⁹ a04, a05, a06, a07, a11, a14, a17, a21, a22, m03, m07, b05

²⁰ a11

were forced to use a tool or a service that were quiet, instead they believed it to be acceptable to be overheard since the conversation did not concern private/personal issues.

Services (frequency of use)		Categories (frequency of use)	
Address book	3	Communication	13
Alarm	0	Information	27
Your position	2	Entertainment	0
Email	1	Planning	0
Fax	0	GIS	2
Friend finder	0	Synchronous	10
Information search	25	Asynchronous	3
Calendar	1	Multi-party	1
Camera	0	Internet	3
Watch	3	Signs	0
MMS	0	Printed material	2
Cell phone	9	Social interaction (official person)	0
SMS	2	Social interaction (known person)	0
Instant message	2	Social interaction (unknown person)	21
Games	0	Picture	2
Phone	0	Voice	10
Video chat	1	Text	7
No aid/tool	12	Video	1
		Hearing	8
		Vision	7
		Dexterity	3
		Cost per use for the user	12
		Mobile	16
		Usage sounds	10
		Stationary/Mobile setting	Mobile

Table 12. Services and service properties in scenario 6.

3.1.6.2 Importance of different context factors

As shown in Table 13, the context factor rated to be most important was that the situation provided a generous amount of time to solve the task. Further, the participants also rated the importance of the noisy environment quite high, since it affected the possibilities to communicate and ask other people in the bar about other places to go to. There were no significant gender difference with respect to rated importance of the different context factors; neither were there any significant correlations between the factors with high respectively low value or between these factors and age. However, there was a tendency towards significance regarding the correlation between high sound level and age ($r=.38$, $p=.015$), where the participants with the highest age thought that the noisy environment affected the way they solved the task to a greater extent than the younger part of the participants.

Context factors	All participants (SD)	Men (SD)	Women (SD)	Sign ($p<.05$)
Disturbance Medium	1.27 (.90)	1.19 (.75)	1.32 (.99)	N.S.
Urgency Low	2.76 (1.58)	2.75 (1.48)	2.76 (.1.66)	N.S.
Sound level High	2.37 (1.71)	2.63 (1.75)	2.20 (1.71)	N.S.
Privacy Medium	1.37 (.86)	1.38 (.88)	1.36 (.86)	N.S.
Attention High	2.07 (1.56)	2.13 (1.59)	2.04 (1.57)	N.S.

Table 13. Perceived importance of the context factors in scenario 6.

3.1.6.3 New services

In this scenario many participants²¹ used no services at all. Their prime solution was to just wander around until they found a place that seemed to meet their preferences.

²¹ a01, a04, a05, a09, a15, a20, a23, stina24, m03, 06, s03, s05

3.1.6.4 New factors

The importance of getting relevant and reliable recommendations was one of the more common factors that the participants²² listed in this scenario. One strategy²³ to obtain this kind of information was to ask people that seemed to have similar preferences. Another way of getting relevant information was to ask a taxi driver²⁴ since “they know everything”²⁵.

The urge to have fun during the hunt for a new place was something that seemed important to a number of participants²⁶. Many of the participants that expressed this need tried to find a new place by social interaction (e.g. asking people on the street) or by exploring the city by their own.

3.2 Contextual factors vs. service properties

Literature suggests that several factors contribute to the need for services in a given situation, of which many are difficult or even impossible to determine objectively at beforehand (Dourish 2004; Greenberg 2001). However, with this analysis, we begin the work of systematically identifying individual factors that may have high impact in certain settings. The long-term goal is to get a data set, rich enough for identifying which factors that, in isolation, in combination with other factors, or in combination with other data (e.g. user input), can assist in predicting relevant services for a given context despite the dynamic and unpredictable nature of actions as complex as selecting services.

In Table 14 we have compiled the frequency of use for a number of service properties as well as the pre-determined factors for each scenario (only properties that are relevant for this text are included, the others are left out for brevity). The properties marked “Synchronous %” and “Asynchronous %” reveal how common the use of synchronous and asynchronous communication were among the participants that used communication services (note that the sum of these may very well be over 100% if one or more participants used both synchronous and asynchronous communication in the same scenario). The “Stationary/Mobile setting” factor has also been added to the set of context factors. In the following analyses the two office scenarios (scenario 2 and 3) were classified as stationary, while the others were classified as mobile.

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Average
Voice	38	32	10	34	37	10	26.8
Text	18	26	38	18	16	7	20.5
Hearing	38	33	18	34	37	8	28.0
Dexterity	1	15	37	1	4	3	10.2
Cost per use for the user	38	10	19	38	38	12	25.8
Mobility	39	22	26	39	40	16	30.3
Usage sounds	38	33	8	37	35	10	26.8
Synchronous %	100%	78%	41%	100%	97%	77%	82%
Asynchronous %	3%	37%	90%	3%	11%	23%	28%
Stationary/Mobile setting	Mobile	Stationary	Stationary	Mobile	Mobile	Mobile	
Disturbance	Medium	Low	High	Medium	Medium	Medium	
Urgency	High	High	Low	High	High	Low	
Sound level	Medium	Low	Medium	High	Medium	High	
Privacy	Medium	High	Low	Medium	Medium	Medium	
Attention	Low	High	High	High	High	High	

Table 14. A subset of service properties and context factors for all six scenarios.

²² a10, a13, a16, a18, a22, m04, b04, s01

²³ a16

²⁴ a18, a22

²⁵ a18

²⁶ a03, a04, a06, a08, a09, a14, a16, a20, a21

Following are a number of correlations between context factors and service properties described.

High disturbance vs. usage sounds – In the only scenario with high disturbance (scenario 3), the frequency of use of sound based services was well below the overall average.

High disturbance vs. text – In the only scenario with high disturbance (scenario 3), the frequency of text based services was well above the overall average.

High urgency vs. cost – In three out of four scenarios with high urgency (scenario 1, 4, and 5), the frequency of services that cost was well above the overall average, in the fourth (scenario 2) it was well below average. In the latter case the participants had easy access to a free alternative.

Low urgency vs. cost – In the two scenarios with low urgency (scenario 3 and 6), the frequency of services that cost was lower than the overall average, in scenario 6 it was even well below average.

High urgency vs. synchronous communication – In three out of four scenarios with high urgency (scenario 1, 4, and 5), the use of synchronous communication was well above the overall average. However, in scenario 2 it was close to average.

High urgency vs. asynchronous communication – In three out of four scenarios with high urgency (scenario 1, 4, and 5), the use of asynchronous communication was well below the overall average. However, in scenario 2 it was higher than average.

In the above two cases, a difference in type of urgency can be noted. In scenario 1, 4, and 5, there is a need to resolve the situation quickly, while in scenario 2 there is a need to spend little time on resolving the situation.

Low privacy vs. voice – In the only scenario with low privacy (scenario 3), the frequency of voice based services was well below the overall average.

Stationary setting vs. dexterity – In the two scenarios with stationary settings (scenario 2 and 3), the frequency of services that required dexterity was above the overall average.

Stationary setting vs. mobile – In the two scenarios with stationary settings (scenario 2 and 3), the frequency of mobile services was below the overall average.

Stationary setting vs. the Internet – In the two scenarios with stationary settings (scenario 2 and 3), the frequency of Internet based information search services was well above average.

There are also examples of hypotheses with no support at all in the results. One such hypothesis is that high sound level would influence the use of services that require hearing (such as cell phones). In one out of two scenarios (scenario 4) with high sound level, the frequency of services that required hearing was even above the overall average. This lack of indication of correlation between high sound level and use of services that require hearing is not in line with our results from the first phase, in which several participants preferred to use e.g. SMS instead of voice communication when in noisy environments. However, a suggestion to an explanation to this is that many participants felt a need for synchronous communication due to other reasons (e.g. high urgency in scenario 4) in combination with a lack of synchronous but non-hearing alternatives in the mobile settings of the two scenarios. Most users resolved this situation by avoiding the high sound level, which was possible by for example leaving the theater lobby or night club temporarily (see section 3.1.4 and 3.1.6 for a more detailed analysis of this).

3.3 Qualitative analysis

In the following section we provide a deeper analysis of which context factors that the participants added. We conclude with discussions about changes in behavior, social aspects of different services, and privacy and disturbance.

3.3.1 Analysis of added factors

During the study several new factors were added. Those that were added either by many participants or brought up in several scenarios are reviewed below. These factors can roughly be divided into three groups. *Circumstances* – factors that in some way add information to the scenario. *Inner state* - factors that describe choices that participants make either to avoid being uncomfortable, or to be more comfortable in a situation. *Task* – factors that affect the outcome of the task that is put forth in the scenario. For example, some participants felt that one task required multi-party communication in order to be solved; others felt that synchronous (or sometimes asynchronous) communication was required.

3.3.1.1 Cost

The most frequently recurring factor added by the participants was the factor of cost. It was mentioned in scenario 2, 3, 4 and 5. This factor seemed to be very important for several participants in some situations. In scenario 2 for example, only ten participants²⁷ chose services that potentially would imply extra costs for them.

In scenario 2 and 3, which takes place in an office environment, the factor of cost had the greatest impact. It can be explained by the fact that the participants had access to free service alternatives. Scenarios where this factor is not mentioned (1, 6), takes place in the city and in a pub, places where the access to free alternative are limited.

3.3.1.2 The information receiver's access and use of services

The friend's access and use of services is a factor that is added to some scenarios (2, 3, and 5), and it was especially common in situations where the participants wanted to use communication services such as ICQ, email or SMS.

3.3.1.3 The importance of lunch vs. friend vs. meeting

Several participants mentioned that for example the importance of work, the importance of eating lunch, or the importance of meeting a friend, affected how they solved the situation. While these factors do influence people in how they solve a situation, they are not included in the scope of context factors that we have actively explored in this study.

3.3.1.4 Type of information

A need for a certain type of information was something that was added to many scenarios. In scenario 5, many participants²⁸ wanted information to be represented in a certain way, for example using a map instead of getting instructions via the cell phone. One example where the nature of information played an important role was in scenario 6, where the participants were looking for a new, better place. Several participants²⁹ expressed a need for reliable and relevant information. To solve the situation 21 participants chose social interaction by asking other people about recommendations instead of getting the information from e.g. a pub guide on the Internet. It seemed like the participants felt that social interaction made it easier to find more dynamic and relevant information.

3.3.2 Changes in behavior

One interesting recurring phenomena is that some participants, when affected by a context factor, preferred to change their behavior rather than the service. Instead of using a message service where no hearing was required they tried to avoid the sound by e.g. walking out from

²⁷ a01, a02, a08, a09, a10, a22, m01, m07, b01, b05

²⁸ a04, a05, a06, a07, a11, a14, a17, a21, a22, m03, m07, b05

²⁹ a10, a13, a16, a18, a22, m04, b04, s01

the noisy place³⁰. Another example is when participants³¹ that preferred to stay still when using a service instead of changing to a service that needed less attention (e.g. cell phone call) and which could be used while walking. In the movie theatre and on the bus some participants³² lowered their voices instead of using a quiet service. In scenario 3, the low privacy and the high disturbance factors affected many participants' choice of services as well as their behavior. Eight participants³³ decided to wait until lunch before conducting their private tasks.

3.3.3 Social aspects of different services

Some interesting social aspects of communication were revealed in the interviews. Different services offered different possibilities for the social interaction. For instance, some participants felt that it was easier to persuade a friend to come along using synchronous communication than asynchronous communication³⁴. This is supported by another example in which participants³⁵ claimed that it was easier for a friend to say no when a suggestion was made using asynchronous communication. The participants wanted to respect the friend and offer a chance to think it all over. Asynchronous communication seemed to open up for a more unrevealing communication (easier to hide you inner thoughts) compared to synchronous communication. One participant³⁶ thought it was inappropriate and cowardly to make an apology via SMS for failing to buy movie tickets. The excuse was instead given via a cell phone. Other participants asked for a richer social communication because they wanted to "feel the mood of the receiver"³⁷. Richer social communication was mainly obtained through synchronous communication.

In scenario 4 seventeen participants³⁸ did not want to buy new tickets or take any new initiative that would affect their friends without a common agreement. Some of the participants viewed it as common sense or as a social rule to show respect in the decision-making process. Synchronous communication was also preferred in this situation – as many as sixteen of these participants (who wanted a common agreement) chose synchronous communication. The advantage of using synchronous communication in this situation could be that it is a fast way to exchange many opinions and an easier way to track the friends' thoughts about a new plan.

3.3.4 Privacy and disturbance

An interesting finding from the study was how the need for privacy differed in anonymous and non-anonymous situations. Few participants seemed to be affected when unknown people could see and hear what they were doing, for example when walking in the street (scenario 1), standing in a movie theatre (scenario 4), sitting on a bus (scenario 5), or sitting in a pub (scenario 6). An explanation given by a participant was that the contents of the conversations or the actions were not sensitive and did not require privacy. Even though the content of the conversation (or actions) was within the same range of sensitivity, it was more common that participants were affected by their limited privacy in the workplace scenarios (scenario 2: average 2.05, and scenario 3: average 3.95). Many participants stated that having to perform

³⁰ In scenario 4: a03, a17, s01; In scenario 6: a13, a22

³¹ In scenario 1: a07, a11

³² In scenario 4: a17; In scenario 5: a13, a21

³³ a13, a17, a18, a21, a24, m01, m02, s03

³⁴ scenario 1, a12

³⁵ a12, a21

³⁶ a01

³⁷ scenario 2, a10

³⁸ a01, a05, a07, a08, a10, a11, a13, a14, a16, a17, a18, a19, a20, a23, m06, s01, s05

private tasks at work affected how they addressed the scenarios. Some of the participants even waited until lunch before performing private tasks (see section 3.1.3) because they did not want to disturb or be disturbed by the colleagues. The participants in the study used different services for the same reason: they chose services that they considered as discrete or in some other way more appropriate. One participant³⁹ used the phone instead of sending SMS because “it is discrete and it looks better”. In scenario 2, several participants stated that the way that they solved the situation was affected by being alone at the office.

The work atmosphere and policy about performing private tasks at work were an affecting factor⁴⁰. For example, if management accepts it, the participants would probably be more willing to perform private duties at work. Even though the scenario did not reveal any information about the company’s policy on these matters, many participants behaved as if the company had restrictions against performing private tasks during working hours.

The factors of privacy and disturbance are highly decisive in a non-anonymous situation, but in the other anonymous scenarios (1, 4, 5, and 6), few participants felt that the fact that they could disturb others had any influence on how they addressed the scenarios. However, the average of the participants rating of the importance of disturbance and privacy in scenario 5 is somewhat higher (disturbance: 1.46, and privacy: 1.54) than the overall average.

Why the participants in the bus scenario felt more affected can be explained by the fact that the level of sound makes overhearing more possible, than e.g. in the crowded movie theatre in scenario 4. Another explanation can be that the people on the bus easier can follow the whole conversation since (except when the bus stops) there is less movement than for example in the lively pub in scenario 6.

In scenario 6, some participants were affected by the factor of disturbance, even though this was an anonymous situation. Some participants⁴¹ did not want to offend the people in the pub by asking for a better place; instead they preferred to ask a neutral person in the street.

4 Discussion

In this section methodological consideration to the use of scenarios is discussed. The method has several advantages; however, it is also important to consider its limitations. Further, the use of the results from the present study is discussed. It is suggested how the results from the study can be applied in the work with developing information systems for context-aware services, as well as suggestions for other ways to approach the data from this study. Finally, new complementary ways to investigate the area further is discussed.

4.1 Methodological issues

Throughout the study the participants were asked to explain how they would act would they experience the events described in the scenarios. The majority of them were likely to answer how they would act in similar situations, since it is more intuitive to describe actions and service use that one is used to. Some participants⁴² felt that they couldn’t select all services because of limited knowledge about them. Other participants⁴³ acted in opposite way by being more playful and choosing new “cool” services.

It is difficult to identify with briefly described situations and it requires a great ability of introspection to answer questions about how one would respond to them. Some situational facts seemed to be more difficult to relate to than other, for example to “feel” and imagine

³⁹ a04

⁴⁰ a10, a12, a16, m04, s05

⁴¹ a03, a12

⁴² E.g. a18

⁴³ a23, a07

oneself in a crowd⁴⁴, or to experience a certain sound level, than to understand the purpose of a situation. To make it easier for the participants, the scenarios were carefully reviewed (first read aloud by the interviewer and then read once again by the participant). This would ensure that parts of the scenario were not neglected. Finally, to control that none of the scenarios were completely divorced from reality, the participants were also explicitly asked to rate their ability to identify with each scenario. In most cases the participants could easily identify with the scenarios. On a scale ranging between 1 (very easy) and 5 (very difficult) the overall average was 1.52.

Although the scenarios were developed to be as realistic and applicable as possible, some of the participants departed the task that was presented in the scenario. In scenario 1, one participant⁴⁵ expressed doubts about wanting to eat lunch with a friend in a stressful situation. Other participants⁴⁶ wanted to skip a moment in the scenario, e.g. the lunch or going out with a friend, in favor to work. In scenario 4, some of the participants⁴⁷ thought it were strange that no movie ticket reservation was made at beforehand. They would have reserved tickets earlier to avoid ending up in such situation. In scenario 5, six participants⁴⁸ assumed that they would remember at least parts of the information (e.g. the name of the bus stop or the address), one of these participants⁴⁹ even expressed that he had difficulties to imagine himself in that situation at all.

In these cases it is interesting to note that few participants had any difficulties to imagine the situations. Rather, the problems seemed to be related to difficulties in identifying with the scenarios. One interpretation of this difficulty is that the participants in question normally avoid short-term planning situations.

4.2 Use of results

The data from the study presented herein, as well as the results from the analyses, are useful for influencing design of information systems with the intended use in uncontrolled environments by large and heterogeneous user groups. The results of the qualitative analysis (see section 3.3) are particularly useful on a conceptual design level.

The results of the analysis of correlations between context factors and properties of services (see section 3.2) could be used directly in order to respond to contexts in which for example high urgency can be detected, the surrounding is sensitive to disturbance (e.g. in a library), or users are confronted with limited privacy. However, it is important to use the results carefully because of the limited number of scenarios explored as well as the relatively small number of participants. It is therefore recommended that the direct use of these results is limited to bootstrapping prototype systems used for evaluations of the effect of the factors, or input to the design of further studies of correlations between context factors and properties of services.

The data from the study can also be further analyzed in order to seek the answers to a number of questions.

Analysis of information searches and communication acts – With the limited set of services to choose from in this study, the correlations between context factor and service properties is rather coarse. With a more detailed analysis of the intentions behind the information searches and communication acts, more fine grained relationships may be found.

⁴⁴ a05, scenario 4

⁴⁵ a09

⁴⁶ a21, b01

⁴⁷ a16, a23, s01, s03, s05

⁴⁸ a09, a16, m02, m03, s04, s05

⁴⁹ a09

Dependencies between different services – The data from the study contains information about how services are combined and in which settings. Therefore a further analysis of the results could reveal interesting information about how to support users by providing (static or dynamic) links between different services. In order to provide valuable results, this would have to build on the analysis of information searches and communication acts mentioned above.

The results are however most useful as indicators of how to proceed in order to further explore this design space. In particular, studies in which patterns in individuals' contexts would make sense. This study is built on the assumption that it is possible to find correlations between some context factors and patterns of service use by large populations of users. However, if the variation between individual users is too large, these results will be weak. There are reasons to believe that this is the case at least in some settings for some context factors. For example, numerous claims of the following kind have been made by participants in both phases of this study: "I usually contact XXX via SMS because she is usually too busy to answer". Following are a few suggestions of how to proceed in order to explore this further.

Follow a small number of people for a longer period of time. Record a large number of factors with high granularity, as well as performed activities within a specific domain. If the study reveals relationships between context factors and performed activities, if only for a small number of individuals, it has been shown that generalizing over context factors of individual users can be useful.

Follow a large number of people in a controlled role play in order to study the influence of a limited set of contextual factors on choice of service. The applicability of the kind of service is more limited than the one mentioned above. However, with a specific target for adaptation, it is likely to provide more fine grained results.

Further more, a larger data set of the kind provided herein would make it possible to analyze dependencies between individual context factors. For example, the results from scenario 4 suggests that the need for synchronous communication in order to address a situation conflicts with the high sound level that potentially would prevent users from choosing a cell phone for communicating with peers.

5 Summary and Conclusions

In the study described herein, several interesting relationships between context factors and the use of services were discovered. High urgency was in several situations considered to be important, and it was also found to have an impact on how the participants chose to communicate. For example, in situations with high urgency synchronous communications was preferred instead of asynchronous communication. The context factor "cost" was introduced by the participants during the study. It seemed to be very important; however, in situations with high urgency it became less important. Another interesting finding was the relationship between privacy and the choice of modality when communicating. The study also revealed a relationship between the risk of disturbing the people in the vicinity and the effort to choose means for communicating quietly.

It is a long and tedious process to capture interesting and relevant context factors in the settings of information system users, learning how to measure them, and finally using the data in a meaningful way when designing information systems. The discussion about where to draw the line between what is measurable and what is not must be kept alive constantly. Large efforts must be placed in finding the factors that are general enough (relevant for many people) and also in some sense measurable.

An underlying goal with this work has been to start the development of a method for finding general context factors, and their relative impact in different situations. Much more

work need to be done before this goal is achieved. However, the method and the results from the studies described herein can serve as a good starting point for future efforts.

6 References

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Appendix I

	Service type					Communication type			Information search type						Modality				Requirements					
	Communication	Information	Entertainment	Planning	GIS	Synchronous	Asynchronous	Multi-party	Internet	Signs	Printed Material	Social interaction (official person)	Social interaction (known person)	Social interaction (unknown person)	Picture	Voice	Text	Video	Hearing	Vision	Dexterity	Cost per use for the user	Mobility	Usage sounds
Address book	x																							
Alarm				x															x				x	x
Your position					x										X	x				x			x	
Email	x						x	x								x				x	x			
Fax	x						x								X	x				x				
Friend finder					x										X	x				x		x	x	
Information search		x							x	x	x	x	x	x										
Calendar				x												x				x			x	
Camera		x													X					x			x	
Watch		x														x				x			x	
MMS	x						x								X	x	x		x	x	x	x	x	x
Cell phone	x					x										x			x			x	x	x
SMS	x						x										x			x	x	x	x	
Instant message	x						x										x			x	x			
Games			x												X					x	x		x	
Phone	x					x										x			x					x
Video chat	x					x										x		x	x	x		x	x	x

Table 15. The mapping between services and service properties.