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# Utilizing Contextual Information for Mobile Communication

**Johannes Knittel**

VIS  
University of Stuttgart  
Stuttgart, Germany  
knittejs@studi.informatik.uni-stuttgart.de

**Albrecht Schmidt**

VIS  
University of Stuttgart  
Stuttgart, Germany  
Albrecht.Schmidt@vis.uni-stuttgart.de

**Alireza Sahami Shirazi**

VIS  
University of Stuttgart  
Stuttgart, Germany  
Alireza.Sahami@vis.uni-stuttgart.de

**Niels Henze**

VIS  
University of Stuttgart  
Stuttgart, Germany  
Niels.Henze@vis.uni-stuttgart.de

**Abstract**

Mobile phones enable us to be reachable by phone calls anywhere and anytime. However, it is not always appropriate to answer a phone call. Even a ringing or vibrating phone can be inappropriate in some situations. The information required to assess if a call is appropriate is split between the caller and the callee. Only the caller knows the importance of the call and only the callee knows her context. Sharing parts of this context with the potential caller would enable the caller to make a better decision. Based on previous work we conducted a survey to learn about the contextual information that users believe to be important for this decision. We derive context information that users will to share and consider relevant and helpful. Further, we present a mobile application that augments users' address book with contextual information that we aim to study in the large.

**Keywords**

mobile phone; phone call; context; interruption

**ACM Classification Keywords**

H.5.2 [Information Interfaces and Presentation]: User Interfaces - evaluation/methodology, user-centered design;  
H.5.3 [Information Interfaces and Presentation]: Group and Organization Interfaces - evaluation/methodology, computer-supported cooperative work.

## Introduction

Mobile phones tremendously changed the way we communicate. Users keep their smartphone in reach for almost 90% of the time [6] which means that they can receive phone calls almost anywhere and at any time. While in face-to-face communication we see the state of other persons and know their context, in telephony communication incoming calls can be obtrusive and inappropriate. In meetings, for example, a ringing or vibrating phone can be disturbing. Incoming calls can interrupt a callee which can result in decreasing the person's performance and increasing the perceived task-complexity [1]. These problems are due to the fact that the caller does not have any information about the callee's context.

Having some information about the current context of the callee before initiating a call can help the caller to decide whether it is an appropriate time to initiate a call. With the advances in technologies current mobile phones can retrieve different information about the context they are used in. In this project we investigate which context information is essential and useful for sharing between a caller and a callee to initiate a call without disturbing the callee. To achieve this goal, an online questionnaire was conducted. The questionnaire aimed to assess which contextual information can be helpful for callers when they want to initiate a call. Further, it investigates contextual information a callee wants to share with callers. The results guide developers for designing contact apps that provide additional contextual information of persons in the contact list. Based on the questionnaire's results a prototype was developed.

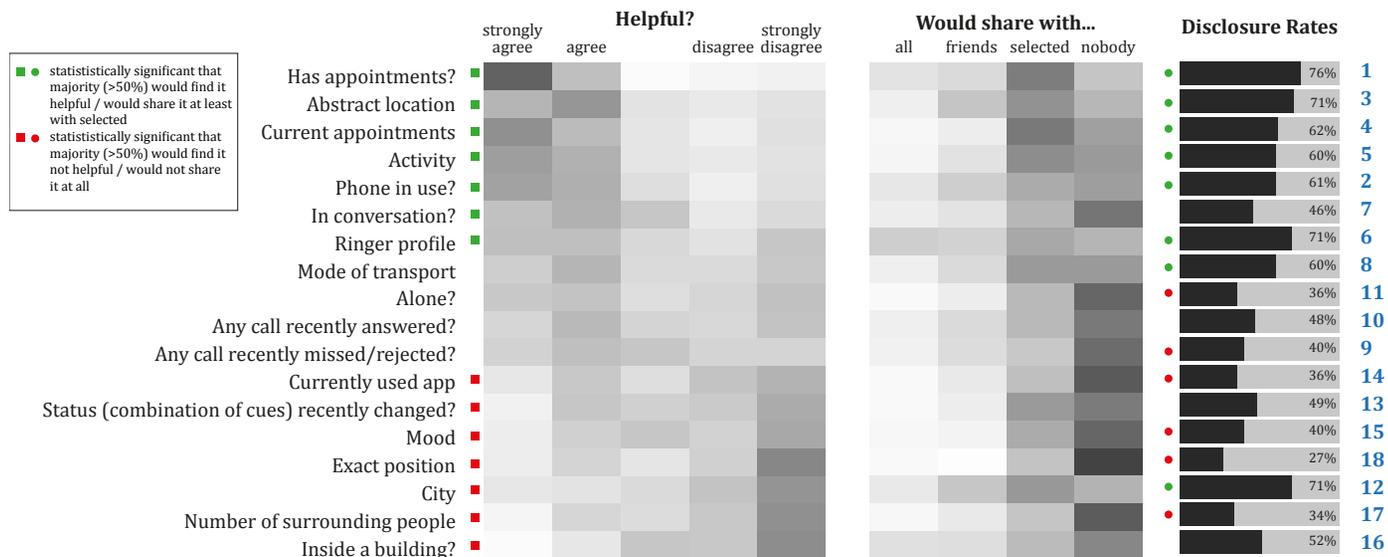
## Related Work

Several prototypes have been developed that provide the caller cues about the callee's context. Schmidt et al. built

a prototype that shared context information to prevent inappropriate interruptions [11]. Users could choose a profile such as 'meeting' or 'at home' that was displayed in others' phone books. Awarenex extended this work and showed other information, e.g., an abstract location, the device used, and appointments [12]. Based on requirements identified, Oulasvirta et al. redesigned smartphone's contact list to show different contextual information [9].

De Guzman et al. investigated which contextual cues might help to decide if one wanted to initiate a communication [5]. They conducted a diary study and found that most of the cues mentioned were related to activities (task status, social and physical availabilities). Several studies investigated which cues people would share. Khalil et al. [8] used experience sampling to determine context information users would disclose. Connelly et al. [3] similarly used a survey and experience sampling.

Previous work, however, came to inconsistent results. Ter Hofte [13], for example, reported an disclosure rate of 20% for 'in company' and 34% for 'in conversation', while Khalil et al. [8] reported 74% for 'in company' and 69% for 'in conversation'. Previous work neither consider all cues that can be determined by current phones nor the trade-off between usefulness and privacy. In this project, we conduct a survey to address a broad range of contextual cues. We determine the relation between usefulness and privacy concerns. The results guide the design of a robust contact app which provides contextual information of persons in the contact list. In contrast to previous work our aim is to distribute it widely to investigate users' behavior in-situ.



**Figure 1:** Results from the online survey. The blue numbers on the right show the subjective benefit rank for the context cues.

## Survey on Sharing Contextual Cues

We conducted a survey to assess the usefulness and the sharing preferences of contextual information between callers and callees. We wanted to reach a considerably larger number of participants compared to previous studies in order to get more reliable results.

### Method

We set up an online survey to recruit a large number of participants. The questionnaire consisted of four parts. The first part included demographic questions. Further, we asked whether they used Internet and surfed the Web with their mobile phone. In the second part we showed a list included 18 context cues (contextual information) and asked to rate how helpful this information is to determine the availability of a callee, using a 5-point Likert scale (1:strongly disagree, 5:strongly agree). Figure 1 includes

the contextual information. In the third part participants should state for each of those cues with whom (nobody, only few selected, friends, everyone) they would share this information. Finally, in the last part we asked participants to provide us any additional contextual cues they believe could be helpful for initiating a call.

The survey was distributed through various mailing lists and social networks. The survey was available for a month. It took approximately 10 minutes to answer all questions. In total 132 participants (54% female) with average age 24.6 years ( $\sigma = 7.92$ ) completed the survey. 86 participants (65%) used Internet on their mobile phones at least sometimes.

### *Results*

The Benjamini-Hochberg [2] procedure was applied with a false discovery rate level of 0.05 to account for multiple testing. Thus, a test result is only considered significant if the corresponding p-value is low enough according to the Benjamini-Hochberg method.

It is statistically significant (Sign test) that the participants find several contextual cues such as appointment, abstract location, or activity helpful to determine the callee's availability (Figure 1 green squares). Whereas other contextual information such as number of surrounding people, exact position, city, is mostly considered useless (Figure 1 red squares).

When it comes to sharing contextual information, over 70% of the participants would share an appointment, their abstract location, their current city, and their ringer profile at least with selected persons. On the other hand, over 65% would share the exact position or the number of surrounding people. The median of all cues is either 'with nobody' or 'with few selected persons'.

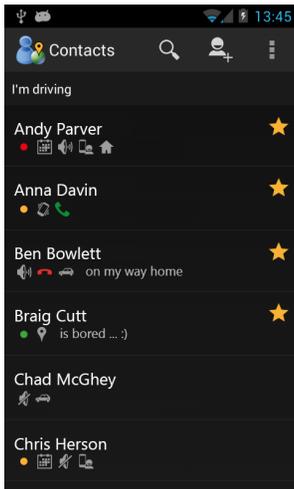
The number of disclosure-events (one disclosure event = participant would share a cue at least with selected persons) in proportion to the total number of events (no-of-cues X no-of-participants) for the male participants is significantly higher in comparison with the female participants (Fisher's Exact Test:  $p < 0.015$ , odds-ratio 1:23). Furthermore, this ratio is also significantly higher between the participants who use Internet on their phones at least from time to time and the participants who hardly use the internet or do not own a (internet-capable) phone ( $p < 0.016$ , odds-ratio 1:24). There is no statistical evidence that men are more likely belong to the group which uses the Internet at least sometimes on the smartphone compared to women, or vice versa.

To compare sharing costs (privacy) and helpfulness of the cues, we multiplied the two means of sharing and helpfulness rating for each cue. Therefore, we converted the ordinal privacy scale to an interval scale (1 to 4). This, to some extent, provides us insights into the subjective benefit of each cue. Based on the results, 'having appointments', 'phone in use', and 'abstract location' are the top three beneficial contextual cues. Figure 1 shows the results for each cue.

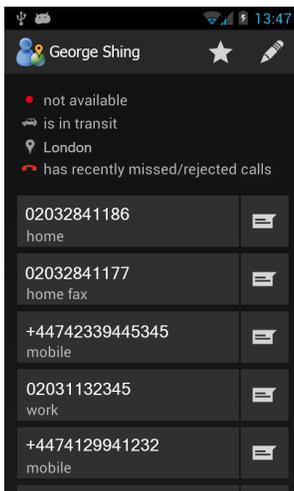
### *Discussion*

The results reveal that over one third of the contextual cues mentioned in the survey are helpful to assess availability of a callee. Having an appointment, abstract location, and current activity are the most useful information for the caller. On the other hand, contextual information such as number of surrounding people, exact position, or being inside a building are considered less helpful.

Regarding sharing this information, the results show that users will to share contextual information as long as the disclosed information is abstract enough. However, they want to have control with whom they share this information. This confirms previous studies [4, 8, 13] report that the social relation has a significant impact on sharing behavior. Similar to Khalil et al. [8], men tend to more likely share contextual information than women. The same trend holds for users that use Internet on their mobile phones compared to users that do not use the Internet on their cell phones. The results confirm Ter Hofte [13] that the majority of users would share their abstract location and would not share whether they are 'in a conversation?' or 'in company?'. Khalil et al. [8], in contrast, report that the majority would share this information. Interestingly, the high disclosure rates reported



**Figure 2:** Address book with context information.



**Figure 3:** Details about a particular contact.

by Consolvo et al. [4] concerning fine-grained location (in a geographical sense) could not be corroborated.

## Prototype

Comparing our results with previous work and the differences between their findings suggest that truly reliable conclusions are only possible by studying in-situ behavior. Therefore, we developed a contact list app for Android phones based on the survey results. In addition to common features of usual contacts apps, it shares and shows available contextual information. Each user is identified by his cell phone number. The app periodically sends user's contextual information and retrieves available context information of users in the contact list.

### Context information

We chose four context information categories based on the survey's results. The app shows the following context information:

**Location and movement** : The current city is inferred from the network-based location. Based on the past locations it is determined whether the user is currently in transit. Additionally, users can tag their current location (e.g. 'home').

**Phone usage** : The app monitors the phone status as well as whether the user recently missed/rejected or answered any call.

**Appointments** : The app checks whether there is an appointment right now in the calendar. It is also possible to disclose further information retrieved from the calendar.

**Manual cues** : The current ringer profile (silent, vibrate, ring) can be shared. Additionally, users can specify their availability in three modes (green, yellow, red) and set a status message.

### Implementation

Figure 2 shows the main screen where all contacts are listed. Context information shared is immediately shown on others devices through small icons beneath the name of the respective contact. At the top of the screen users can search their contacts, add new contacts, and set their status message. The button on the right opens a menu to manually set the availability, tag the current location, and open the privacy settings. The app allows users to specify with whom they want to share each context information. Four groups are proposed: everyone having the phone number, contacts, only favorite contacts, nobody.

By selecting a contact, a view including all available context information is shown (Figure 3). Furthermore, the user can initiate calls or send a message. The bar at the top of the screen allows to (un)mark the contact as a favorite and edit the entry.

Deploying an application to the field imposes several challenges. The app has to run stable in different environments on various devices. To maintain user experience, it is indispensable to avoid severely decreasing battery runtime, deal with the lack of sensors as well as noisy data, and preserve users' privacy. Therefore, the complete communication is encrypted and additionally secured against replay attacks. Furthermore, a special protocol keeps the traffic required at a minimum. The use of periodic background agents minimizes the power required.

## Conclusion and Future Work

In this paper we described our work in progress towards studying context sharing in-situ. Based on previous work we conducted an online survey to investigate the relationship between user's willingness to share context cues and their expected helpfulness. We showed that most of the

context cues with a good ratio between benefit and privacy could be implemented on current smartphones. We also found that people willed to share some contextual information, but they wanted to be in control with whom they share it. The results used as the input for the design and implementation of a robust contact list application for smartphones.

The results of the survey can only approximate the users' in-situ opinion and behavior. We assume that other methods, such as experience sampling and diary studies, share this limitation. There is only one approach to reliably study the sharing of context cues for mobile communication. Similar to our previous work (e.g., [7, 10]) we are in the process of deploying our application widely using mobile application stores. The main challenge here is to reach a critical mass that makes the application useful.

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