

Context Information in Mobile Telephony

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Abstract. Most research in context-aware computing offers definitions of context that consist solely of measurable information. Using mobile telephony as an example of a computing area, we provide a set of context information relevant to the area drawn from a qualitative case study: identity, location, time and present activity. After arguing that these context measures are not the same for other areas of computing, three guidelines for designing context-aware features for mobile telephony are provided. We conclude that context information should be defined for the area in which the researcher is present instead of attempting to provide an overall definition of context.

1 Introduction

Context-aware computing describes the applications or devices that adapt according to situational variables [1]. Since it was coined in 1994 [4], numerous definitions of *context* have been provided, both in relation to the development of context-aware applications and in relation to theoretical contributions to the area. The first studies defined context as environmental measures, where more recent definitions acknowledge that context is more than that; for example they also include features such as the individual's internal state. However, until now, no common view or definition has been dominant.

To counteract this search for a broad ranging definition of context, the goal of this paper is to analyze and rank-order context information for a specific domain: Mobile telephony. The purpose of this is to provide the area with guidelines about which context information should be supported in context-aware applications. The domain is chosen as an example of an area that is likely to benefit from context-aware features. The context information is found through a case study exploring the use of mobile telephony and its communication facilities.

First related work in the field of context-aware computing is reviewed, and second, the case study of mobile phone use is presented. Third, the findings of context information are presented and we provide three guidelines for designing context-aware applications for mobile communication. Finally, we conclude and suggest further research.

2 Context-Aware Computing

Context-aware computing is a recent area of research and through the last decade, many context-aware applications have been developed. Context-aware applications include the Olivetti Active Badge system [7] and the Conference Guide [2]. The first application is a stationary service, rerouting phone calls to the phone closest to the individual and the latter is a handheld guide for conference attendants.

The early work often only defined *context* in terms of measurable information. Schilit and Theimer defined it as location, nearby people and objects and changes to those objects [4] and many researchers just added new sensor information to the list in their definition of context [2, 5]. Other, more theoretical approaches, claim that context is a fluid notion, not possible to describe in terms of measurable variables and that a definition should comprise such vague measures as the individuals previous experience [3]. The difference between the two approaches is that application oriented research defines context in relation to their application, where theoretically oriented research attempts to provide a broad definition of context that can be used in the general area of context-aware computing.

Unlike general context-aware applications, only a few applications focus on mobile telephony and even fewer are actually employed in real consumer devices. An example of a context enabled application is the context-call application by Schmidt et al. [5]. It enables the user to preset his/her context, for example, to settings like 'meeting', 'working' or 'at home' and have the information available to potential callers. Context-aware applications actually used in mobile telephony today include location tracking features offered by some phone service providers [6].

3 Case Study and Research Method

The context measure study was designed as an exploratory case study of context measures in mobile telephony. By interviewing high-level users of mobile telephony, the users' contextual cues of the communication situation are traced. The study consists of eight qualitative interviews carried out in the participants' own environment. It was structured into six parts with questions regarding demographics, three measures of context, general use of mobile phones and a scenario. The purpose of the study is to trace the context information in play in mobile communication and to obtain results that can help in providing guidelines for designing context-aware applications.

3.1 Participants

The participants were selected among heavy users of mobile telephony, to get the most thorough insight into their use; their age range is therefore fairly young. People with a variety of occupations were chosen to get broad range of mobile phone use among the participants. The details are listed in table 1.

Participant	Age and gender	Occupation	Had a mobile phone for
p1	21, female	Service assistant	7 years
p2	21, female	Retail assistant	3 years
p3	25, male	Graduate student	7 years
p4	26, female	Graduate student	6 1/2 years
p5	21, male	Military service	6 years
p6	27, female	Freelance consultant	7 years
p7	19, male	Unemployed	4 years
p8	29, female	Research assistant	6 years

Table 1: Participant description.

4 Four Pieces of Context Information

The participants all express that their reactions and behavior within their use of mobile phones depend on the overall situation. When elaborating on the more specific situational cues, the information that they exchange and rely on in their communication is fairly consistent. A surprisingly few number of specific measures are in play; the participants mainly mention four. Some other measures are also mentioned but have, according to the participants, limited influence on the overall situation. These secondary measures include whom the person is together with as well as time of day. The specific context information that the participants consider as part of the overall situation is ranked by importance according to the participants:

- Identity of the other person
- Location of both communicators
- Relative time of the receiver of the call
- Present activity of both communicators

Identity is the major factor in communication situations; the participants all agree that how they act and react depends highly on who they are communicating with. This information is technically supported by caller id, meaning that the information is (usually) available immediately in the conversation.

Location is ranked as the second most important context measure that users rely on, which supports the development of location tracking applications in mobile telephony, such as location tracking service mentioned in section 2. Location, however, is a complex piece of information because participants refer to it at several levels of detail, such as in a specific building or office, or ‘on the bus’. These nuances are difficult to support technically.

Although time seems to be a simple piece of context information, the finding was that actual time did not matter very much to the users; relative time, defined as the communicator’s time limit before a new activity, on the other hand, was important. Many of the participants inferred, as one of the first things, if the receiver had ‘time to talk’. This piece of context information is fairly complex and important to support by technological means, however, because it is a fairly

important part of the context in mobile telephony, the information should not be ignored in the design of context-aware applications.

The finding that present activity is an important context measure supports the applications that facilitate the display of activity information [5]. However since it is ranked last, these types of applications might not be as relevant as claimed and a more simple version of this function could be a profile tracker based solely on location information.

One relevant observation is that users seem to be satisfied with how the context is already communicated verbally. The exchange of context information is in many cases even seen as a positive part of the conversation, which opens up the question if context-aware functions are appropriate to mobile telephony. The findings of the case study resulted in a set of guidelines that should be observed in designing context-aware functionality for applications in the area.

5 Guidelines for Context-Aware Mobile Services

The case study illustrates that the context information relevant in the mobile communication situation is very different from other areas of computing. For example, the use of stationary work stations where location information is less dominant if not unimportant. Based on the findings of the case study, the following guidelines for designing context-aware applications for mobile telephony are proposed:

1. Provide context information at the time of the users' need
2. Make sure that it is not more desirable for the user to obtain the facilitated context information in another way, e.g. verbally
3. When context information is too complex to support technically it can be broken down to sub-information for the user to interpret

Each guideline is exemplified by context information from the case study: Considering guideline 1, for example, the context information of 'present activity' is not relevant to anyone at anytime; it should be displayed only to potential callers, for example after the number is dialed, but before the call has been put through. The second guideline is derived from the result that users often *want* to infer context information verbally. Context information such as location of the receiver is also difficult to acquire technologically; displaying the position of the user's closest GSM antenna will in many cases only give a fragmented notion of where the person is. Therefore this information is more easily communicated verbally at the moment of communication. An example of applying the third guideline relates to the participants' need for relative time information. This is a complex piece of information not measurable by technology; it is likely that breaking the information down to display the next scheduled appointment provides at least a partial notion of relative time.

From these guidelines it should now be evident that it is not appropriate to use an overall definition of context to develop context-aware applications; the context information differs according to the domain of interest. It is our belief

that researchers should analyze context information for their domain in order to facilitate the design of context-aware applications, instead of attempting to provide an overall definition of context as a concept.

6 Conclusions and Further Research

We have stated how defining context in relation to context-aware computing can lead to confusion about how context information should be handled in research. We suggested limiting the definition to a special area, mobile telephony and after reviewing work in context-aware computing, we presented the case study, which provides the foundation for context information that comprise the communication situation in mobile telephony. Finally, we provided three design guidelines for developing context-aware computing in the area of mobile telephony. We concluded that a wide-ranging definition of context is not useful for designing actual applications, but that each specific area needs to find which context measures are relevant to support.

Because of the study's qualitative nature, the suggested guidelines could benefit from quantitative research. It should also be considered how people perceive actual context-aware features in mobile telephony, to evaluate the actual need for these interactive features and the provided guidelines.

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