

# ON CONTEXT-AWARE ARTIFACTS AND SOCIALLY RESPONSIBLE DESIGN

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## **ABSTRACT**

*Context-aware artifacts are of particular interest to HCI researchers as the user's interaction with artifacts moves from rather static desktops to less well-structured environments. Most work in developing such artifacts appears to be technology-driven by which we mean that often not much time is spent on exploring and clarifying the underlying concepts of context. In this paper, we attempt to contribute to the discussion of context by outlining an explicit distinction between the concept of context as a characterization of a situation and the situation itself which we understand as a social construct in the first place. Acknowledging this difference suggests that designers of context-aware artifacts should pay particular attention to the fact that the context determined by context-aware artifacts may differ from what the persons involved in a social setting have negotiated. In such a situation, it should be possible to overrule the context-aware artifact in such a way that the artifact's behavior does no longer interfere with the situation that has been negotiated among peers.*

**KEYWORDS:** Artifacts, context, context-awareness, situation, negotiation, frame problem

## **1. INTRODUCTION**

Context-aware artifacts are of particular interest to the HCI community as the interaction with artifacts and their interfaces moves from rather static desktops to less well structured environments. When referring to computational artifacts, context-awareness means that artifacts are to some extent able to sense the context in which they are being used. The idea is that artifacts determine the actual context of their use and adapt their functionality to what their designers considered helpful in the respective context.

An almost classical example for the potential benefit of context-aware artifacts is a context-aware mobile phone. As Hull et al. (1997) put it: "Who really wants their mobile communicator to ring while in the midst of a theatre audience?" A context-aware mobile would use context aspects, such as the user's identity, the user's location, and the user's current schedule, to determine the level of intrusiveness that would be appropriate when trying to notify the user of incoming calls. Notifications could range from ringing (quite intrusive) to buzzing or vibrating (less intrusive). The mobile even might suppress notifications of less important calls (not intrusive at all).

Context-aware artifacts are here (Bellotti and Edwards 2001) and they are to stay. Most work in developing context-aware artifacts, however, appears to be technology-driven by which we mean that development is driven by what is technically feasible rather than by what might be helpful in a situation. The difference between these two approaches matters if we consider social aspects that cannot be sensed by currently available technology (see below for examples). As a consequence, the context determined by context-aware artifacts may differ from what persons involved in the situation experience. Often, not

much effort is spent on clarifying unexpected and unwanted implications of context-aware artifacts (and technology in general).

In this paper, we attempt to contribute to the discussion of context by making an explicit distinction between the concept of context as a characterization of a situation and the situation itself which we understand as a social construct in the first place. We argue that some of the difficulties with artifacts making use of context arise because of the fundamental difference between context and situation: while a situation is open to interpretation and (re-)negotiation, the opportunity is lost once a situation is characterized as context. Acknowledging this difference suggests that users should be able to overrule a context-aware artifact in such a way that the artifact's behavior does no longer interfere with the situation negotiated among those participating in the situation.

We proceed as follows. First, we discuss a definition of context that seems to be typical for a lot of research in context-aware artifacts. Based on this definition, we outline the difference between context and situation. Then, we discuss the role of (re-)negotiation in the usage of artifacts and outline why this is problematic for context-aware artifacts. Finally, we draw our conclusions and outline future research directions.

## **2. A DEFINITION OF CONTEXT**

In the anchor article of the 2001 HCI special issue on context-aware artifacts, Dey et al. (2001) review several definitions of context. They start with the definition given in Webster's Dictionary: "the whole situation, background or environment relevant to some happening or personality" and argue that this definition it is too general to be useful in context-aware computing. Considering some other definitions as well, they finally provide a definition of context that is based on information that characterize a situation and that are relevant to the interaction between a user and its application:

"Any information that can be used to characterize the situation of an entity, where an entity is a person, place, or object that is considered relevant to the interaction between a user and its application, including the user and the application themselves. Context is typically the location, identity and state of people, groups and computational and physical objects." (Dey et al., 2001).

This definition as well as most other definitions of context indicate that context is related to situations but the nature of this relation remains unclear. It seems that "situation" comprises "everything" while "context" consists of specific aspects that were distilled from a particular situation in order to characterize that situation. Examples for such aspects provided by Dey et al. (2001) include location, identity, and state of people, groups and computational and physical objects. Hull et al. (1997) list identity, locations, companions, vital signs, air quality, and network availability as examples of context aspects. Accordingly, it seems to be reasonable to define context -as used in context-aware artifacts- as a model or a representation of a particular type of situation.

## **3. IMPLICATIONS OF USING CONTEXT**

Acknowledging that context is a representation of a situation has various implications. In what follows we discuss the most important ones.

### ***3.1 Context and the Frame Problem in AI***

The frame problem (e.g., Pylyshyn 1987) is one of the hard problems in classical representation-based artificial intelligence. Roughly, the frame problem is about what aspects of the world have to be included in a sufficiently detailed world model and how such a world model can be kept up-to-date when the world changes. However, the world is constantly changing, intrinsically unpredictable, and infinitely rich (Pfeifer and Rademakers 1991) and the frame problem has shown to be intractable at least in the general case. Lessons learned from investigations of the frame problem suggest that there is little hope that research on context-aware artifacts will succeed in overcoming the problem that context -understood as a representation of a situation- is always limited. The frame problem is indirectly addressed by Greenberg (2001) noting that for context-aware artifacts it may be difficult or impossible to determine an appropriate set of canonical contextual states. Also, it may be difficult to determine what information is

necessary to infer a contextual state. Grudin (2001) makes a related point when he argues that "[...] capturing context digitally alters it fundamentally. The context that is captured is removed from its context, namely the context that is not captured".

Of course, the hardness of the frame problem does not suggest to abandon research on context-aware artifacts (such artifacts are here and they are to stay) but to keep in mind that such artifacts may well fail when trying to recognize a situation.

### *3.2 Context and Situation*

The relevance of the frame problem suggests to further explore the relation of context and situation. Research in situatedness (e.g., Suchman 1987; Clancey 1997) is interested in the specific characteristics of usage contexts and situations. Contrary to most research in context-aware artifacts, however, research in situatedness understands the characteristics of a situation as resources for (human) cognition and (human) action in the first place. This means that research in situatedness is not so much interested in isolating specific aspects but in understanding how and to what extent these aspects influence cognition and action when used as resources.

The term "situated" has its origins in the sociology literature in the context of the relation of knowledge, identity, and society. It is in particular the social connotation of the term "situated" that allows to highlight the differences between "context" as a characterization of a situation and the "situation" itself. "Situation" is the physical and social environment in which situatedness -using a situation as resource for action- occurs. A "situation" is an observer-independent and potentially unlimited resource that is *always* open to re-interpretation. "Context", to the contrary, is an expression of a certain interpretation of a situation is observer-dependent and therefore no longer open to re-interpretation: the meaning of aspects included in the context description is more or less determined and other potentially relevant aspects may not be included in the context description.

The openness to re-interpretation matters as (individual) users may decide to assign significance to aspects of the environment that were not considered as significant before. Related to this is that users may decide to use artifacts in a way that is different from what has been envisioned by the artifact's designer. Based on their capability to "use" situations as resources, humans are not only able to use artifacts according to the (assumed) intentions of their designers but humans are also capable of creating novel usage situations that are different from what designers originally envisioned. Referring to phenomenology, Dourish (2001) outlines that designers may influence how artifacts are being used but they have no absolute control. Meaning arises in the course of action: the meaning of a technology is not inherent in the technology but arises from how that technology is used. A regular hammer can be used to illustrate the point. In most cases, such a hammer will be used according to the (assumed) intentions of the hammer's designer. However, a hammer could also be used as a paper weight. This particular usage may not be envisioned by the hammer's designer but its weight, its shape, and the specific circumstances of the situation in which a paper weight is needed allow to do so. In this sense, even the use of an artifact by a single isolated person involves negotiation based on socially developed knowledge about the nature of the artifact, knowledge about its common use and its intended use.

The situation is even more complicated if more than one person is involved. Cars or powerful computers on one's desktop are technically more advanced examples for illustrating how the use of artifacts may be re-negotiated. Both artifacts can be used as effective tools for transporting things and processing data, respectively, but both may also function as status symbols (Wenger, 1998). Context-aware artifacts are not involved in such negotiations which means that they are hardly able to recognize the outcome.

### *3.3 Context and Negotiation*

Situations are always subject to negotiation among the persons involved in the situation. As Lave (1991) puts it, "learning, thinking, and knowing are relations among people engaged in activity in, with, and arising from the socially and culturally structured world". There is little doubt that context-aware artifacts may provide benefit in certain situation *if* the context they sense fits what participants in the situation have negotiated. However, as Agre (2001) notes, context-aware artifacts may fail annoyingly as soon as a context-aware system's (wrong) choices become significant.

Agre (2001)'s argument draws from the observation that people use the various features of their physical environment as resources for the social construction of a place, i.e., it is through their ongoing, concerted effort that the place--opposed to space--comes into being. An artifact will be incapable of registering the most basic aspects of this socially constructed environment.

Context-aware buildings (also referred to as cooperative buildings) are a nice example for the potential benefit and pitfalls involved. Using currently available technology, a room in such a building could monitor its electronic schedule, the number of persons in the room, and the prevalence of business clothing among the persons in the room. The room could compute that the current context is a "business meeting context" and could instruct attendees' mobile phones not to disturb the meeting and business-related information could be projected onto the room's multi-purpose walls.

However, being a social situation in the first place, a meeting does not only depend on the already mentioned aspects but also on what has been negotiated among the participants. This means that even if a particular situation fits the description of a "meeting context", the situation may have changed into an informal get together and vice versa. The subtle changes are hardly recognizable as commonly mentioned context aspects, such as the ones mentioned by Dey et al. (2001) (location, identity, state of people, groups and computational and physical objects) may not change at all. In a sense, the context does not change while the surrounding situation does. Examples for such situational changes are unexpected breaks or being well ahead of the schedule so that a meeting finishes earlier than expected. Once the meeting has changed its nature, it may no longer be appropriate to block mobile calls and it may no longer be welcome to project business-related information on walls (as it would demonstrate that the hosting company's expensive technology did not recognize an obvious change in the meeting situation).

Robertson (2000) provides a nice example of a business situation that changes although all 'indicators' that could be sensed by artifacts do not appear to undergo recognizable changes. Conducting a workplace observation in a software company, Robertson attended weekly meetings over a period of seven months, making separate video and audio recordings of relevant meeting activities. One of the questions to answer was what designers were doing during these meetings. Robertson reports:

"Amongst the talk, laughter and other activities, there was clearly a pattern to each meeting. Individuals reported what they had done while apart. Others would ask questions and each person's work would be discussed by the group. Then another person would report on her work. This process continued until everyone, who had worked on the project through the week, had told the others what she had done. Reporting was always followed by a period of shared designing, where the group worked together on some aspect of the design. Then, towards the end of the meeting, the work for the next week would be negotiated and allocated."

Robertson notes that from an observer's perspective it would be easy to divide the group's meeting into different stages, such as reporting, discussion, shared design, negotiations of future work, and finally allocation of work. One of the central findings of the workplace observation, however, was that the participants in the process did not describe their work with such labels: "[...] they did not bother with names for specific stages in their work, as they lived it, at all". Robertson concludes:

"[...] naming the stages in the design work in this way excludes entirely the work of coordination and negotiation that made the process they represent possible in the first place. Moreover, this communicative work had been identified by the designers themselves as the work they most wanted supported."

The most important point for this paper about context-aware artifacts is how the process was going on:

"[...] people did all these kinds of cooperative design work while sitting round a table talking together. At times they moved around the room, entered or left the room and moved various objects around; but there were no formal changes of position, no discernible interactional difficulties and certainly no upheaval when they changed from one kind of work to another. [...] Whatever they did was always accomplished by different combinations of their purposeful, embodied actions "

As Robertson notes, the latter was not a particularly original insight as it has been recognized by a variety of people before. However, these people are researchers from theoretical traditions including

ethnomethodologists, practitioners of interaction analysis, computer-supported cooperative work researchers, exponents of distributed cognition, and so on. We feel, however, that these insights have not yet received the attention they deserve in the discussion around context-aware artifacts.

#### 4. IMPLICATIONS FOR THE DESIGN OF CONTEXT-AWARE ARTIFACTS

Hull et al. (1997) describe the potential value of context-aware applications (they actually use the term situated applications). Areas where artifacts are expected to provide benefit include augmented reality, providing localized information, context-based retrieval, situated reminders, appropriate behavior of devices, and monitoring. Hull et al. (2001) provide concrete examples of situations in which users may benefit from the capabilities of context-aware artifacts:

⑩ "Where is the nearest pizza restaurant?"

⑩ "Get me the document I was reading on the train yesterday"

⑩ "Remind me to buy some tooth paste when I am next near a supermarket"

⑩ s(our interpretation of the augmented reality setting described by Hull et al., 2001)

It is important to note that in all of these situations it is the user and not the artifact who assigns significance to specific aspects of the environment: aspects of the environment that suddenly become significant are pizza restaurants, a specific document, toothpaste, and a cherry tree in a particular garden. All of these aspects are part of the user's environment but the aspects only become significant because the user makes the (informed) decision that these aspects are significant in relation to his or her current situation.

Bellotti and Edwards (2001) outline that in many situations where context-aware systems have been proposed or prototyped, human initiative is frequently required to determine what to do next. They conclude that two key features must be supported by context-aware systems so that users may make informed decisions based on context: intelligibility and accountability. By referring to intelligibility, Bellotti and Edwards (2001) argue that context-aware systems must be able to represent to their users what they know, how they know it, and what they are doing about it. By referring to accountability, they argue that systems must enforce user accountability when they seek to mediate user actions that impact others.

There is little doubt that demanding for intelligibility and accountability will help gain a better understanding of responsibilities involved in the design of context-aware artifacts. It is questionable, however, whether intelligibility and accountability help overcome the inherent limitations of context-aware artifacts. Similar demands have been discussed extensively in the artificial intelligence field in the context of expert systems and robotics. The problem is that *explaining* inferences works best with rather simple settings and it is increasingly difficult the more complex the setting is. Projecting *future* implications of proposed actions is even harder. Now the crux is that Bellotti's and Edwards's (2001) demands for intelligibility and accountability are only necessary in settings that are already so complex that context-aware artifacts are no longer able to -or not allowed to- make decisions on their own, i.e., without human supervision. Accordingly, demands for intelligibility and accountability are likely to be intractable when applied to complex real world settings.

#### 5. CONCLUSIONS AND FUTURE RESEARCH

In this paper, we have provided an explicit distinction between context and situation and we have outlined that significant characteristics of situations are lost when situations are reduced to context descriptions. Furthermore, we have related the creation of context descriptions to work on the frame problem in artificial intelligence in order to argue that demanding intelligibility and accountability unlikely to help overcome the general limitations of context.

There is no doubt that context-aware systems are here and that they are to stay. First, this means that it is an empirical question in which situations and to what extent intelligibility and accountability will help

design better systems. Gadgets, such as mobile phones are likely to become the testbed for the next generation of context-aware artifacts. Second, given the inherent limitations of context modeling, designers of context-aware artifacts should take care that users are able to overrule a context-aware artifact in such a way that the artifact's behavior does no longer interfere with the situation negotiated among those participating in a situation. Mobile phones can be switched off but more complex artifacts may be more difficult to 'overrule'. Sometimes, as in the case of a context-aware alarm clock, it could even make sense if the artifact may 'decide' to resist overrule (switch off) attempts. Third, it will be interesting to observe whether users will overrule annoying artifacts or whether they slowly adapt to certain annoyances as in the case of mobile phones. Finally, we are interested in the question whether context-aware artifacts are indeed able to deliver the benefit expected. In most cases, people are well aware of their situation and have quite some expertise in using artifacts in an appropriate way (e.g., most people turn off their mobiles during a theater audience because they *know* that mobiles ringing during theater audiences are annoying). People also good at recognizing situation changes as they are part of the negotiations that lead to changes. What is the benefit of making artifacts context-aware over making artifacts easier to use?

## 6. REFERENCES

- Agre, P. E. (2001). Changing places: contexts of awareness in computing. *Human-Computer Interaction*, 16(2-3).
- Clancey, W. J. (1997). *Situated cognition*. Cambridge University Press.
- Dey, A. K., Salber, D., and Abowd, G. D. (2001). A conceptual framework and a toolkit for supporting the rapid prototyping of context-aware applications. *Human-Computer Interaction*, 16(2-3).
- Dourish, P. (2001). Seeking a foundation for context-aware computing. *Human-Computer Interaction*, 16(2-3).
- Greenberg, S. (2001). Context as dynamic construct. *Human-Computer Interaction*, 16(2-3).
- Grudin, J. (2001). Desituating action: digital representation of context. *Human-Computer Interaction*, 16(2-3).
- Hull, R., Neaves, P., and Bedford-Roberts, J. (1997). Towards situated computing. In *Proceedings of the First International Symposium on Wearable Computers (ISWC'97)*, pages 146-153, IEEE.
- Lave, J. (1991). Situated learning in communities of practice. In Resnick, L. B., Levine, J. M., and Teasley, S. D., editors, *Perspectives on Socially Shared Cognition*, pages 63-82. American Psychological Association, Washington, DC, USA. Third Printing April 1996.
- Pfeifer, R. and Rademakers, P. (1991). Situated adaptive design: toward a methodology for knowledge systems development. In Brauer, W. and Hernandez, D., editors, *Proceedings of the Conference on Distributed Artificial Intelligence and Cooperative Work*, pages 53-64. Springer-Verlag.
- Pylyshyn, Z. W., editor (1987). *The robot's dilemma: the frame problem in artificial intelligence*. Ablex Publishing Corporation, Norwood, NJ.
- Robertson, T. (2000). Building bridges: negotiating the gap between work practice and technology design. *Human-Computer Studies*, 53, 121-146.
- Suchman, L. A. (1987). *Plans and situated actions - the problem of human-machine communication*. Cambridge University Press.
- Wenger, E. (1998). *Communities of practice: learning, meaning, and identity*. Cambridge University Press. First Paperback Edition 1999.