Experiencing Technology before it exists: A Case Study

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1 Introduction

Ubiquitous and wearable computing have been around for more than a decade now [15]. However, there is still no consensus on what the new technologies are going to be used for. Traditionally, application development in ubiquitous and wearable computing communities has been mostly technology driven. This has lead to a variety of applications of which only few are really being used in practice, e.g. [2, 4, 6]. This may be seen as an indication that current practices are too unsystematic and rely too much on developers' and designers' intuition alone.

We found that there is a latent tension between a technologically advanced solution and the focus on the user. For the introduction of advanced new technologies, such as ubiquitous or wearable computing, users usually cannot be familiar with this new opportunities and often have difficulties realizing its benefit [1]. Simultaneously, designers and developers often lack the understanding of the relevant issues in specific working domains. In order to create solutions that really go beyond incremental changes of established routines, these limiting boundaries have to be overcome: Real innovation is not generated by technology itself, but technology can act as a vehicle to create new opportunities that innovate and change established routines and work practices.

This paper consists of three main sections. Section 2 lists and discusses a set of requirements which, in our experience, help to introduce and generate new applications that aim to depart radically from today's work practices. Section 3 describes the notion of *X'treme Prototypes* as a method to generate innovative applications. Prototypes, referred to as *X'treme Prototypes*, are used as vehicles to provide a grasp of how future implementations could look like regardless of their immediate feasibility. Finally, section 4 reflects on how well the *X'treme Prototype* method fulfills the initially posed requirements.

2 How to build innovative applications

This section discusses various requirements an application development method should meet in order to produce innovative ubiquitous and wearable computing applications. This list of requirements is based on our own experience to introduce innovative applications as well as on discussions with other researchers.

Early stage support: Currently, designing ubicomp and wearable computing still means designing for the early stage (which is different than writing task descriptions for creating use cases as suggested by software engineering disciplines [13]): designers are still looking for ideas and user needs applications might solve. Whereas methods from software engineering [13] and HCI have a long tradition in describing efficient processes for developing customized applications, they do not support the search for compelling problems that radically depart from today (as ubiquitous and wearable computing aim).

Balanced user involvement: Instead of the typical asymmetry between developers and users (users have needs, developers fulfill them), both parties have to productively learn from each other in a complementary partnership.

Radically depart from today: The most important challenge is to create innovative solutions which may radically differ from current practice. It is not enough to 'just' fulfill the user's 'incremental' needs. Rather the solution may enable and stimulate a fundamental and effective change in work practice.

Multiple stakeholder involvement: In the course of different projects we realized that meeting the end-users of applications is necessary but not enough. The important point is to talk not only to the final end-users who may be most affected but also to other parties and decision makers in order to gain a more holistic view and obtain stimulating input.

Stimulation of stakeholders: We experienced that users and other stakeholders are often locked into their world and work practices. This makes it difficult for them to look beyond daily practice and imagine new and innovative solutions. However, presentation of new concepts that are concrete and graspable (but not necessarily ready-to-use) can initiate fruitful discussions .

Mediation between users and developers: Users and developers have to be empowered to view beyond established routines and to envision prospective opportunities for change. This information has to be shared in a way which both parties understand.

Developer guidance: A development process should provide clear single steps that guide the developer towards a final development goal. Only if a development method provides enough guidance for the developers, it will be useful for a wide audience.

[1] as Don Ballman mentioned in a panel at InterCHI'93 [1]: *users are afraid of disrupting established routines and are unaware of technological advances.*

Exploratory nature: In contrast to traditional product/software development for creating innovations the goal is rather to exceed the user's expectations. This means, there has to be more than only validating specifications with the customer. One has to discover relevant problems by experimentation, by trying out, and touching new concepts: stakeholders should be able to explore and reflect on alternative approaches.

Yield feasible results in the end: For a successful development method it is essential that, after a number of iterations, it yields feasible results. This does not necessarily mean a ready-to-use product, but at least an output that developer and user consider to be useful.

Allow for multiple cycles with the user: The basic idea of multiple cycles [**?**] allows the developer to take advantage of what was learned during the development of earlier versions of a system. However, learning should come from both the development and the cooperation with the user.

Rapid development cycles: Many development methods such as extreme programming [3] or rapid prototyping [14] aim at meeting the user's expectations in short converging cycles. Short and fast cycles are the premise for several iterations during a project life.

Use of toolboxes: Toolboxes are a technical prerequisite for rapid developments. Re-using frameworks and architectures over and over again is a key factor for short development cycles. Though re-usability in ubicomp is still in it's infancy the benefit has been acknowledged and partly addressed for software (e.g. Context Toolkit [12], Context Fabric [8]) and hardware (e.g. Smart-Its [5]).

3 The *X'treme Prototyping* Method

Many if not all of the requirements listed in section 2 are addressed at least individually in various approaches of software engineering [13], user-centered design [11], and participatory design [7]. We feel, however, that none of the current approaches does respect all of them sufficiently well in order to generate and create innovative applications and application scenarios for ubiquitous and wearable computing. This section therefore presents a method called *X'treme Prototyping* which is synthesized from various well-known approaches.

To overcome the tension between user-focus and the introduction of radically new concepts and technologies the application of so-called *X'treme Prototypes* are used to explore new principles and future user needs in cooperation with stakeholders of a specific domain.

1. **Choose a compelling problem domain.**
   This suggests to deliberately choose a problem domain that simultaneously allows for a successful integration of research results and a meaningful grounding in a user's domain.
2. **Understand the user's application domain.**
   The goal of this phase for the developers is to gain a clear understanding of the user's ultimate goals, driving forces and constraints of established routines, and the current implementation of work practices.
3. **Distill radically new concepts by identifying new opportunities for change.**
   The result of this phase should be a new concept that helps users to solve at least one of their goals in a new way regardless of the current implementation looks. Obviously, this phase is the most creative part of the presented approach.
4. **Develop an *X'treme Prototype* to present one or several radically new concepts to the user.**
   This step develops a prototype that can represent and illustrate the strengths of one or several concepts to the user.
5. **Provide experience for the users and stimulate users and stakeholders.**
   This phase aims to provide hands-on experience of new concepts by using an *X'treme Prototype*. As such users and stakeholders should be stimulated to articulate future needs and imagine new possibilities beyond their daily practice and knowledge.
6. **Iterate, several iterations may be necessary to let the process converge.**
   Deliberate incorporation of user feedback (from the previous phase) should be used to revise the concept (Step 3) and result in changes of the prototype (Step 4). The iteration process can be stopped if, firstly, developers are confident with the new innovative application and if, secondly, the users judge the application to be generally feasible and useful.

4 Discussion and Conclusion

By posing a list of requirements (Section 2) we characterized how an ideal development process should be composed for innovative application development in ubiquitous and wearable computing. Then *X'treme Prototypes* where introduced as a development method for ubiquitous and wearable computing aiming to respect those requirements. We now want to reflect on the challenges these requirements pose when applying *X'treme Prototypes* in practice. Our experienced is based on two projects: avalanche rescue using wearable sensing technology (A-Life) [10] and applying sensors in professional skiing [9].

In both projects we experienced that the two requirements *Radically depart from today* and *Balanced user involvement* are both central but at the same time create a tension due to their very different nature: For example during early discussions about the benefits of wearable sensors in avalanche rescues with mountaineers – as the actual end-users – we felt a strong and general reluctance against technology. This reluctance, while being an important issue, was a major obstacle during the early stages of the project which hindered progress significantly. From that we learnt that the distillation of opportunities in isolation from users and the preparation of an *X'treme Prototype* illustrating new concepts can help to overcome this tension. Furthermore, when we presented our concept to alpine emergency physicians we were encouraged to continue with our project. *Multiple stakeholder integration* proved important in order to broaden our scope to the entire field instead of depending on perspectives of single stakeholders. In both projects *X'treme Prototypes* helped our stakeholders to think beyond established routines. The presentation of a radar sensing heart-rate in the A-Life project and sensing platform for skiers immediately yielded in a *stimulation of stakeholders*: a black-box device recording life signs, different sensor placements etc. were proposed. This clearly showed that providing the context of work through an *X'treme Prototype* can help stakeholders to better express their needs and think beyond. As such, this immediately provided an understanding of constraints posed by practical limitations, e.g. velocity is a very desired feature in skiing, but sensing is very difficult. This grounding of our concept into the users' work context supported the *mediation between users and developers*. Regarding *developer guidance* we experienced that there is a limit of providing systematic guidance towards innovative development, since creating innovation is a process of creativity. This creativity must not be hindered by the process. Nevertheless, as much guidance as possible without eliminating creativity is a desired goal. Working towards several prototypes sets clear goals without restricting creativity. *Exploratory nature* is key for stimulating stakeholders. Nevertheless, especially during the skiing project we had to cope with the difficulties of providing a small light-weight early robust prototype to be worn by a skier outdoors in a cold environment. For future developments it would be useful to reuse this gained knowledge, as such *use of toolboxes* is a very important goal to follow for ubiquitous and wearable computing in order to enable *rapid development cycles*. Unfortunately, this is not yet the case. *Yield feasible results in the end* is difficult. Nevertheless, in the A-Life project we could arrive at a stage that a Swiss avalanche beacon manufacturer plans to integrate the final results of that project into the new generation of devices. In the skiing project we have the commitment of Swiss Ski to continue with further testing and application in training sessions with the national team.

In conclusion, using the proposed *X'treme Prototype* method we experienced open discussions revealing new and innovative issues since the *X'treme Prototype* provides hands-on experience. In our opinion, this combination of technological change and the revision of established practices may lead towards real innovation. However, other researchers and practitioners from HCI and design might argue that processes similar to the one presented are current practice. We strongly argue however that the ubiquitous and wearable communities are very seldom using those techniques and many researchers might not even be aware of the potential benefit using any of them. This is why we think listing and discussing the above requirements is beneficial.

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