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Mobile Collaboration with Wearables

Introduction

My interest in the evaluation of technology-supported collaboration in co-located environments comes from a project where this is a central challenge for a number of reasons. Here is an overview of the project.

The project is called wearIT@work and has set out to develop wearable computing technologies into an effective tool for users in industrial and professional domains, following a strong user-centred design approach and also dedicating substantial work to non-technical aspects such as work sociology and organizational context. It started June 2004 with a duration of 54 months and is funded by the European Union under its Sixth Framework Program. It is the biggest civil project on wearable computing worldwide, bringing together 36 key players from industry and academia, as well as partners from the four application domains of automotive production, aircraft maintenance, emergency response and healthcare.

Developing support for collaborating professionals is one of the main goals of the project. This aspect is explicitly addressed by a sub-project on Mobile Collaboration, addressing the full range of fully co-located to fully distributed collaboration, which I am heading. This sub-project will conduct research in all four application domains with a focus on the emergency response partner, which is the Paris Fire Brigade. Incidentally, I am also responsible for the project's user-centred design process which includes extensive and continuous evaluations. For these reasons I have a very strong interest in evaluation of co-located technology-supported collaboration.

Vision

In this section I will briefly outline the most relevant aspects we intend to address in supporting mobile collaboration with wearable technologies. This will include some pointers to potential impacts on individuals, group interactions and social dynamics. It will also prepare the following section where the challenges for evaluation are laid out.

To set the technological frame, let's define[1] wearables as all pieces of technology that a person can carry around without any or negligible disturbance to her or his primary tasks. Such technologies include devices for computing, input and output, sensing and connectivity. Visions guiding the development of wearables include making them physically unobtrusive, such as when being integrated with clothing or tools, and having them produce only a minimal cognitive load, such as when providing information without requiring focal attention. These on-body technologies may be complemented with off-body technologies, such as devices for a communication network or localisation system which may be deployed in an ad-hoc fashion. On the functional level wearables allow capturing highly detailed information[2] about the users' current condition and the environment and

[1] This is a working definition only. The distinction from mobile technologies is difficult and probably there is no useful sharp distinction. Also, what constitutes negligible disturbance does not only depend on the technology but also on the level of its appropriation, as is the case with normal glasses.

[2] Such as the user's heart and breathing rates, temperature, skin resistance, as well as the position, orientation and movements of her or his body. Environmental information includes other people or devices in the user's vicinity, including their respective properties.

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to provide him with information and services that are highly adapted to this situation in terms of type, level of detail and form.

In particular, next-generation wearable technologies will provide communication channels that enable people to have a contextually very rich perception of their interlocutors' situation, enabling what might be called a virtual co-presence. In remote collaboration, this is discussed as the expert's look-over-the-shoulder when providing assistance. On a conceptual level, this means that through interconnected wearable technologies physically distributed collaboration can acquire qualities of co-located collaboration.

The ability to provide mobile users with rich and context-specific information and broad communication channels will also increase their ability to take semi-autonomous or autonomous user decisions and actions[3], creating a corresponding shift in collaboration patterns. A corollary of this is that wearables and corresponding communication infrastructures have the potential to greatly support ad-hoc collaboration through discovery of potential collaborators, informing about their capabilities, mediating communication, and providing flexible and adaptable collaboration patterns that may also support a gradual evolution from poorly structured ad-hoc collaboration to more controlled forms[4]. An important aspect of ad-hoc collaboration is that it is likely to produce unanticipated collaboration patterns.

In our research the use of wearables within professional user teams will be of particular interest. In such teams members learn and train to effectively carry out their job. Typically, this includes learning about the capabilities of their team members and building up trust to rely on them. Following the communities of practice concept, we understand such teams as establishing and sharing a joint practice with specific ways of communicating and collaborating that enable efficient performance as a group. The great potential of wearables is that they can be closely integrated with human activities to seamlessly support such practices. But optimal overall performance of course requires a two-way process: the technology has to be adapted to the specific work practices without jeopardizing qualities such as trust and the work practices have to evolve to make use of better or new kinds of support. For example, wearables could largely enhance group awareness and group perception, as when collaboratively assessing a situation.

In the wearIT@work project there are four application fields with obviously rather different types of collaboration, each consisting of specific actors, tasks and collaboration patterns. In the case of our main application partner, the Paris Fire Brigade, collaboration takes place in high risk environments, requiring risk-minimizing collaboration patterns that provide fall-back solutions when technological support should fail[5]. Also, emergency response organizations are highly interested in monitoring as much as possible everything that takes place during an intervention. This information is not only of the highest value for synchronous control during operations but also for subsequent analysis to instruct debriefing and training. With this additional function for wearables of being observational instruments we come to the section about evaluating collaboration.

[3] For example, the US Department of Defence believes that the future "Warfighter Information Network-Tactical" (WIN-T) that provides secure satellite-based multi-media communication between soldiers and command makes the costly set-up of local command posts unnecessary.

[4] Think of emergency response teams from various nations that are being sent to an earthquake area and now have to (or should have to) establish and evolve effective forms of collaboration.

[5] The technology itself should be gracefully degrading, which is to say that small failures should not compromise the whole system, allowing as much as possible the use of whatever remains intact.

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Experiences & Challenges

Experience. Little experience is available on the evaluation of collaboration with wearables, at least in the civil sector. Evaluation of mobile technologies on the other hand has now a few years of history. My personal experience includes standard evaluation methods as typically used in ethnography, such as participative and non-participative observation and different types of interviews. Also, I have experience in conducting controlled laboratory experiments for single-user systems. Finally, based on interaction logs from mobile collaboration systems (including sensor data), we did social network analysis and task performance analysis. This experience comes from both professional systems development and research at Fraunhofer FIT (see Bio). At Fraunhofer we evaluated users that carried out adaptations of groupware systems, i. e. that could not see some of the effects of their adaptations, in terms of comprehension and performance. We also conduct usability studies on a regular basis in our Usability Lab, for example of mobile devices. On a methodological level, I've been working on a consistent and sufficient use of evaluation in user-centred design processes.

Challenges. The Vision section has discussed the kinds of impacts on individual work practices and group interactions to be expected from wearable technologies. Users are likely to modify the way they carry out certain tasks and also will carry out new tasks. In order to arrive at a close fit between the technology and the work practices adaptations will be required on both sides, requiring in turn instructive evaluation of technology use. Given the high level of integration of wearables with situated work practices and therefore typically long appropriation by users, evaluating wearable technologies is particularly difficult. Evaluations have to take place under real working conditions as much as possible and to obtain sound results on performance, users typically have to be at a certain training level with the system. When evaluating a new system version, one is faced with the dilemma that a new user group would allow for an unbiased evaluation but is difficult to train to the exact same level to yield comparable results. While the impact on collaborative performance is a matter of life and death in some cases (e. g. with the fire fighters), it depends on factors that cannot be observed directly and are hard to quantify even indirectly.
In the wearIT@work project one general result we wish to obtain from evaluations is a matrix that sets classes of typical tasks against options for wearable computing support and describes the conditions and context under which a given kind of support is suitable for a certain task. To this end we are faced with the problem of evaluating our four application domains in a way that covers all the major dimensions (comprehensiveness of the sample) and yields results that can be integrated and generalized (methodological consistency)[6].
Finally, the problem of evaluating highly situated activities can be faced in two ways. One is to define (semi-realistic) test tasks and environments[7] that allow for easier

[6] Of course there is no methodology that makes our four domains fully comparable. To some extent they are simply different. The point is that through e.g. a smart choice of tasks more complete and generalizable results can be obtained. And the question is how to be smart about this.
[7] In the case of the Fire Brigade there is a long-standing tradition of setting up training sites and training sessions. It will be very instructive to learn to what extent and how these help to obtain viable results. A possible outcome of this might be to use Virtual Environments for *certain* types of evaluation.

evaluations and then learn how to transpose these results back to the field. Especially for socially complex activities this is known to be very difficult. The other way is to conduct evaluations directly on-site which requires innovative approaches to conduct evaluations that have formerly only been done in laboratories, such as eye-tracking or monitoring of other physiological parameters. As mentioned above, when evaluating the use of wearables a particularly interesting approach is to work on the data that is available from sensors and interaction devices anyway, potentially complementing them with dedicated devices for evaluation purposes.
At Fraunhofer FIT we plan to explore both of the above possibilities and look for a good combination.

Workshop goals

My goal for this workshop is obviously to learn about the other participants' experience with evaluating technology-supported collaboration. In the above text I pointed out a number of difficult questions about evaluation methodology and technique that I would like to discuss. I hope that the workshop will give me impulses for directing research within the wearIT@work project and I would like to discuss with the other participants the highly instructive application domains in which evaluation will take place and our evaluation approach which will include aspects from sociology, psychology and ethnography. By the time of the workshop first empirical results from the domains will be available for discussion.
Additionally, I would be very interested in a discussion about a future research roadmap on evaluation methodology for technology-supported situated collaboration. Especially, because I plan to conduct another project in the near future that deals with this aspect in an innovative and systematic way.

Bio

Markus Klann studied computer science and philosophy at the Universities of Hamburg, Germany and Bordeaux, France, working on the distinction between personal and group knowledge processes and the support for e-learning communities. He then worked for three years in the Mobile Solutions Group of Bertelsmann mediaSystems as a senior software architect, heading the development of a mobile Dating Community, a multi-language, multi-device mobile e-commerce system and a multi-device mobile issue management system. Since two years he is working at the Fraunhofer Institute for Applied Information Technology in Sankt Augustin, Germany, working on e. g. collaborative end-user development, e-community support, context-aware mobile systems and user-centred design methodology. This year, he started working on the European Union's 54 month Integrated Project wearIT@work, being responsible for the project's user-centred design approach and heading the sub project Mobile Collaboration. He will finish his PhD on mobile collaboration probably sometime next year.