Evolving Practices of End User Articulation in Software Co-Design

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Abstract

Participatory design (PD) has a long history and originated in the democratic framing of design activities for workplace settings. The research field of PD investigates methods and tools which involve users in (re-) design activities. In order to meet the user's needs, the co-design of software systems should be initiated at an early stage and continuously adapted. A variety of activities help to establish a more successful design process, including the reflection of requirements and design alternatives or evaluation of prototypes. The main scope of this thesis is the exploration of new forms of remote participation and interaction technologies for co-designing software.

Social technologies change the way in which users are involved in PD. One of the cases presented in this thesis provides results from a long-term study with users from an online community. The aim was to co-design a new product in a democratic way, covering all relevant design and development steps. In another case study, the design of a similar system was applied with users of local households. The results of this study provide insight into how a process like this differs from a distributed co-design applied online.

The results of both co-design studies emphasize the importance of integrated toolkits which support the users in generating feedback within the context of use. Based on this, two concepts were developed: Infrastructure Probes and a Cross Platform Feedback tool. The evaluation of these tools carries several implications for how feedback processes can be stimulated and moderated. In another design case, the digital pen technology was customized for non-expert users. By drawing services, or by using existing visualizations of services, the participants were able to interact with a software system in an intuitive and easy-to-use manner.

All case studies presented in this thesis refer to new organizational and technological forms of involving non-expert users directly in software co-design. As an implication for design, a more integrated PD process is required along with qualitative reflection in the beginning as well as distributed participation as far as prototypes are available. The usage of integrated feedback channels builds the link between use-time and design-time.

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Contents

1 Introduction

1.1 Motivation

Feedback from users is of high importance with a view to incorporating their needs in the design process. In order to develop functional and easy to use software systems, users should be involved at an early stage of the design process but also in a continuous manner. Participatory Design (PD) has been a well-established field of research for more than 30 years now [24, 37]. PD has its origin in the design of software systems for workplaces, but is also gaining an increasing impact in other areas, including the use of software at home and in domestic settings.

The co-design of software systems, especially for special interest solutions, requires flexible forms of user involvement. With the increasing impact of social online technologies, PD can be applied in a distributed manner [77, 45]. Social technologies, such as forums, blogs and web diaries, enable new forms of distributed PD whereby users can contribute remotely in different phases of a design project [77]. Users can provide feedback on visual concepts [64], prototypes can be shared [54], and in this way online product communities are gaining importance in continuous software improvement [150]. Although several studies have described the advantages of remote participation, none of the known studies reflect in depth a complete co-design process involving users from an online community. A more profound reflection would help to understand all the phases of co-design, starting with a discussion of requirements, framing of the decision process and the evaluation of early alpha versions.

Another important approach to co-designing in close collaboration with potential users is referenced as Living Lab [60]. Living Labs are real world environments that support different stakeholders in cooperating and interacting. Users from local households participate in a more long-term manner by providing ideas and evaluating concepts in daily life. Compared to remote forms of participation, close cooperation with potential users helps to understand the current practice of technology use in a profound manner. It seems especially important to understand the advantages and issues, compared to online studies with distributed user involvement.

Instead of only involving users sporadically in certain steps of design, infrastructuring is an integrated methodological approach [140] that goes beyond 'designing before use'. Use innovations may also occur in practice, when users are dissatisfied with a particular functionality or when interesting new ideas develop. In order to capture such situations and to bear them in mind when improving a product, use time and design time need to be linked more efficiently with each other. Toolkits for design should support a direct reflection in context of use. Existing approaches include the visualization of a potential product as an online mock-up [64], and feedback channels that are directly integrated in the software [183]. Regarding the approach of infrastructuring, in-situ design work requires more integrated concepts that support users to reflect about certain technical and non-technical aspects of the environment. Toolkits for co-design need to be conceptualized so that flexible discourses about certain aspects of use-innovations and breakdowns become possible.

1.2 Research Questions and Structure of the Thesis

Participatory design is a process that can be supported in different phases of a software development project. PD methods can be distinguished in two dimensions: user involvement (active and passive) and timing (early or late) [124]. Other classification can be divided in 'design before use' and 'design for design' (meta-design) [51]. In order to include all the activities which are relevant for design (understanding of culture, activities applied before use, continuous improvement of the information systems), a more comprehensive approach is the concept of infrastructuring [170]. Infrastructuring has been described as:

> *"a methodological approach to develop methodological and tool support for all stakeholders' activities that contribute to the successful establishment of an information system usage"* [170]

The approach of infrastructuring refers to an integrated perspective on the design of systems embedded in sociotechnical environments. In comparison to a more traditional approach which can be defined as 'design before use', infrastructuring includes a continuous design process among different stakeholders, also encompassing existing work, culture and learning activities. Infrastructuring can be separated into three phases: infrastructural background work (e.g. culture of use, working standards); preparational design (e.g. learning about technology, programming) and in-situ design work (tailoring, appropriation). Points of infrastructure occur in cases of breakdown or when technology- or practise-induced innovations arise.

In this work, the infrastructuring concept is used as a methodological approach for investigating and reflecting about different case studies of software co-design. Although originally considered for IT design in organizations, infrastructuring activities also support a continuous form of co-design and improvement of home technologies. The case studies presented in this thesis include a co-design process with users from an online community, co-designing with local households and tool support for in-situ design activities. The cases refer to background work (e.g. gaining an understanding of the context as well as the culture of using existing technology), preparational design (e.g. discussing and reflecting mock-ups) and in-situ design work (documenting breakdowns or possible improvements). Based on this structure, the following research questions are addressed in this thesis:

How can home technologies be co-designed with users from online communities?

- *What are the limitations of a co-design process with users from an online community?*
- *What motivates a company to establish a co-design process with an online community? And what motivates users to participate?*
- *What are the major issues when allocating the main responsibilities among user representatives within the co-design process?*
- *What impact do social technologies have on the organization of such a design process?*

How can home technologies be co-designed with users from local households?

- *Which differences arise when applying a co-design process with users from an online community compared to a process with local households?*

How can toolkits support co-design activities in use contexts?

- *How can feedback processes be stimulated with regard to design issues in use contexts?*
- *What are the requirements and design implications for feedback options that are integrated in usage practice?*
- *How can digital pen technology support non-expert users in adapting systems in-situ?*

1.3 Structure of the chapters

The thesis consists of three main sections: foundations, findings and reflection. Chapter 2 refers to the foundations of PD, reflecting relevant literature in the field. This state-of-the-art includes the variations of co-designing with social technologies, the close cooperation with local households (Living Lab), and toolkits that support a profound understanding of practices and which also support direct interaction in use contexts.

In chapter 3, the main findings related to the research questions are summarized. The studies are framed along two main categories: processes support for infrastructuring (with users of an online community and with local households), and a toolkit for co-design that supports the better integration of users in design activities. The results are provided in form of papers that have already been published in peer-reviewed journals and conference articles.

Processes that support the co-design of home technologies

- **Chapter 4: Co-design with online community users** This chapter reflects on a co-design study, initiated by a company, in which users of an online community are closely involved in the design process of a new product. In a design process which lasted more than one year, users contributed towards defining the requirements and evaluating alpha versions. The entire process was applied in a distributed manner. The users discussed in online forums; decisions were made during calls; requirements were released in a wiki system. The resulting alpha versions were shared with all interested users. Thus even evaluation ensued remotely.

- **Chapter 5: Co-design with users of local households** This chapter summarizes the findings from a study of co-designing a software system together with local households. The result was a media centre system partly similar to the system developed in the online study. The design process however differs completely. A small subset of local households contributed to the development in a very structured and formal manner. The pre-design phase started with an in depth empirical exploration of the context, involving the users in diary studies and personal interviews. Afterwards, ideas and mock-ups were reflected in creative workshops.

Tools that support the co-design of home technologies

- **Chapter 6: Infrastructure Probes** Cultural Probes are well-established methods which empower users to reflect on their environment, to share ideas and visions. The concept of Infrastructure Probes adopts the toolkit approach in supporting continuous forms of infrastructuring. Infrastructure Probes are designed to help users document any kind of problems and potential optimizations. Such points of infrastructure may refer to aspects of both software and hardware, but also to descriptions of organizational relevance. An evaluation of the concept provides insight into the value of the concept and highlights potential for further improvement.

- **Chapter 7: Cross Platform Feedback Tool** Motivated from the co-design study with users of an online community, the concept of a cross platform feedback tool goes beyond a single support feedback channel. When reflecting ideas and prototypes, feedback should have a direct reference to the context. This approach implies screenshots of the user's ideas, issues and potential improvements from every platform, and comment with all other devices. In further work, this type of toolkit can support activities for infrastructuring in a highly integrated manner.

- **Chapter 8: Involving non-expert users in reflection on processes** In comparison to toolkits which support the reflection of infrastructures, the concept presented in this case enables non-expert users to adapt a system directly. By using digital pen technology, users can collaboratively exchange information about the process models they are involved with. These models are semi-automatically transferred to a digital representation, and can potentially be linked directly to a productive system. The results of the study show the value of such technology, and show the impact of linking physical and digital representation.

- **Chapter 9: Empowering non-expert users to adapt software systems in-situ** This study shows the value of digital-pen based systems that enable non-expert users to adapt even complex activities directly and more intuitively. Virtual functionalities are mapped to physical representations on paper or stickers that can be arranged easily in a preferred order, e.g. to create a personalized channel list for TV shows. Services are uncoupled from fixed virtual interfaces and users can create their own personalized representations. The evaluation of the concept shows the value of such an approach and also provides interesting ideas for further work.

Chapter 10 summarizes the results of the case studies by discussing the aforementioned research questions. The studies provide a detailed understanding of how co-design and infrastructuring of home technologies can be applied in different ways, supported by various toolkits. Process variations include co-design with members of an online community and co-design with local households. Toolkits include support for documentation and adaptation in context of use. Based on these implications, further improvements are discussed. A separate sub-chapter reflects an integrated design perspective.

2 Participatory Design

2.1 Foundations of PD

Traditional design methods are focused on the professional designer with his or her (re-)design competencies [137]. Research on Participatory Design (PD) explores and investigates different modes and levels of participation of the users. On the one hand there is a normative, emancipatory direction grounded in IT design for workplace systems, which is also referred to as Scandinavian direction [19]. One important aspect of this is the influence employees have on the design of the information systems with which they will be working. Another view is the pragmatic, production-oriented perspective, wherein user involvement is seen as a fundamental approach to designing successful products. Different sub-goals become relevant in PD and, depending on the context, are more or less focused: efficiency, rationalization, usable software, ergonomics, market success etc. PD needs to mediate among the interests of different stakeholders and balance respective (sub-)goals, in the sense of a resolution of paradoxes between discourses in a design situation [50], see also the following definition.

> "Participatory design is, as we see it, no longer primarily a professional issue for software developers, but has to be extended to the relationships between different user-designers, and, beyond that, between them and their clients/customers/ service-seeking citizens in general." [45]

Participatory design as referenced by Bodker et al. [24] means a process of mutual learning among different stakeholders including user representatives and designers. Genuine participation is a continuous form of user involvement in order to reach a common understanding of current practices and requirements but it is also a process to discuss the boundaries and conditions of the design context. One can distinguish between use time and design time. An issue in PD is the anticipation of the use during design time. Users may discover mismatches when they actually use the software. Ehn describes two PD arenas [51] as a design for use and a design for design. In the former instance, PD has attempted the unattainable in trying to fully anticipate use before actual use (see definition). The meta-design approach, in contrast, aims at a design flexible enough to enable continuous adaptation. This is closely related to the concept of infrastructuring [169, 170]. The concept of infrastructuring is related to a design in use that involves all stakeholders over a longer period of time. Infrastructuring can be triggered by different needs, for example by users who are dissatisfied with software, who cannot reach their goals or who find it difficult to use.

> “Participatory design ... exists ... with a special focus on people participating in the design process as co-designers. ... all these approaches [including user-centred design, contextual design, experience design] try to meet the challenge of anticipating, or at least envisioning, and designing for use before it has actually taken place.“ [51]

Participatory design can be applied by using different methods and tools [164, 165, 25]. Depending on the context, there are several participatory-oriented approaches which focus on use and usability (user-centered design), on a certain situation and context of use (contextual design) and on the creation of an experience for the user (experience design). PD exists in different design contexts where the focus is on people participating in the process as co-designers [51]. But how such participation processes are managed, how they are applied and which role users have may differ. User participation includes user representatives having access to relevant information and the opportunity to take independent decisions as well as the participation in decision-making, the availability of appropriate participatory development methods and also room for alternative technical and organizational arrangements [37].

There is a broad spectrum of activities during the different stages of the design process, more or less abstracted and contextualized. Participative techniques can be classified in two dimensions [124]. The first dimension refers to the involvement, by observing the user or by active forms of discussions. The second dimension is related to the timing of user involvement in the design process. Several methods can be used including observation, self-documentation techniques, interviews and workshops [124], but also company-driven activities including support hotlines, bulletin boards and trade fairs [108]. It has been demonstrated to be advantageous to adopt co-design activities at an early stage [31] and profit from a method mix [108].

2.2 Continuous user involvement and social technologies

The Living Lab approach [53, 60] provides methods and tools to involve users long-term. Users who participate at different stages of the development process, also referenced as returning participants, provide more effective feedback because they are already familiar with the concepts and the context [180]. Within a Living Lab, services and products can be designed and evaluated collaboratively in real-world environments [53]. This real world feedback enables understanding of how users accept new technologies in everyday practice. Practical experience in adaptation can be gathered from different environments of such a lab, including controlled lab environments and real world households as well as virtual environments. Living Labs can be set up so that the innovation process is driven bottom-up by long-term collaboration among diverse stakeholders [20].

The management of a participation process with heterogeneous users, the anticipation of their usage and their experience is a challenge for PD [24]. Social technologies provide new potential for distributed user involvement. Interested users participate in online discussions and can span boundaries between users and developers [9]. Online environments provide space for remote participation [77]. Contributions from community members help the designers to reflect on their work. Companies can build virtual prototypes for the internet and collect feedback and ideas for optimization [64].

> Articulation Support: "Support for technology-related articulations (real and online), providing a shared (online) articulation sphere (e.g. web forum, tool-embedded discourse)" [137]

Given the definition in [137], articulation can be supported in a variety of forms, e.g. by using web forums and feedback tools. Different technologies enable support for face-to-face and online activities, to be used in-situ, synchronous and asynchronous [24, 124]. When designing for domestic contexts, there is a trend towards using well-designed tools which stimulate feedback and articulation, e.g. in a more playful manner [15], or to play around (technology probes, [102]). Even for work contexts, methods need to stimulate participation in a creative and engaging way, e.g. to provide a pleasurable little extra at work [118].

Social technologies enable a broad spectrum of remote participation in the wild. However, mutual learning in PD in the sense of profound understanding of context and user needs cannot always or entirely be covered by standard questionnaires and online polls. New forms and possibilities for participation processes are required to benefit from online environments that support different design steps. Users can reflect on visual prototypes [64]; they can exchange views and opinions via email and standard internet tools [54]. Users can also provide enriched feedback using mobile phones [99] and they can further organize themselves in communities to adapt and extend existing products [151, 150]. Several studies are available which experiment with these forms of user involvement. However only a marginal number of works explore the implications of applying this kind of involvement long-term.

Articulation of users in PD can be supported in manifold forms, ranging from face-to-face to more mediated forms of cooperation with physical and online technologies. Commented case studies are an example of shared documentation for improving design [130]. A group of users who adopted a software system documented their experiences during usage. This documentation was subsequently passed to another group of users, who commented and added to the description. In employing this method, the designer receives feedback on the current state of use. In addition, the stakeholders themselves learn from other practices by sharing their experiences. There are many ways to support distributed participation activities, including diaries [32], probes [26] and online tools [51, 45].

2.3 Co-design with users of an online community

Today, software development is often a highly distributed process [71]. Development projects are planned and set up in a distributed manner and management requires the flexibility of the stakeholders involved. Social technologies enable new forms of participation in the wild [45, 77, 78]. Users can contribute in a distributed manner, by brainstorming new features or by concept testing. The distributed involvement of users early in the design project can be described in three potential strategies which include socializing the research, bridging the gap between existing and future practice, and developing early content [78]. However, the usage of these technologies also faces some issues in comparison to more traditional forms of user involvement. Due to a heterogeneous user group [51], users are geographically distributed and potentially anonymous [37, 51] and co-design activities are more difficult to manage.

The process of seeding, a metaphor often used in PD literature [78, 58], is employed in order to stimulate participation. Seeding content is important to move design from abstract to more concrete forms of realization. Seeding is possible with living research prototypes [29], environments that empower users to act as designers [55]. However, the usage of digital self-reporting created similar paths of seeding [78]. Technologies like mobile blogging are adapted by participants for different goals which resulted in new and interesting usage scenarios.

Product communities, sometimes referenced as communities of consumers

[191], are of high interest for companies as they provide feedback, report problems and also help each other. Such user-user cooperation continuously supports the improvement of a product, and also supports effective forms of marketing [112]. Often the users are highly motivated to contribute in order to help create a new version that better addresses users' needs. Further sources of user motivation are fun, curiosity, a desire to learn, personal interest, acceptance by others, and access to exclusive information [151, 150]. In return users appreciate receiving feedback from an official employee. The attention paid by the company is rated more highly than the recognition of the other users.

Depending on how open the development process is structured, a co-design process can be influenced by the feedback that users provide in online communities. Such a close form of cooperation is reported especially in open source software development [9]. But this kind of user cooperation is becoming more and more important for commercial software providers, too [64]. Users organize themselves in interest communities [191], and provide valuable feedback for improving a product further on [168]. Users - not necessarily lead users [149] - can contribute to the design by using online tools for social exchange. For more experienced users, the modification of existing standard software is also an option. Jepessen and Molin [151] report a case in which the modification process of commercial software had not been intended initially. However, seeing the potential of such contributions from community members, the company started rethinking and began to support the community activities by providing more open interfaces [150].

Involving users in commercial software design is not trivial; the question of adequate user representatives can be crucial [25]. User representatives in the classical sense of PD have adequate representatives in the online world. So-called gatekeepers are people who have the confidence not only of the users but of the employees, too. Referred to as cross-participants [9] or moderators in general [94], they know the domain and also know what happens around a product: they know the problems, issues, requests etc. They filter relevant information from a broader user base, are in contact with the developer or company representatives, and canalize important information. Gatekeepers play an important role since they participate in different media and discussion spaces and are therefore informed from different perspectives.

Social technologies offer new ways for users to contribute in co-design activities. The feedback from the users can be used to adapt software directly, e.g. in case of software bugs, but can also be used as a shared knowledge base for the various stakeholders involved [184]. Community Help in Context [183], for example, is a wiki-based help system that enables users to extend and modify help descriptions related to the current context. Online and remote participation can also be supported by new variations of self-documentation techniques such as mobile probes [99] and technology probes [102]. Virtual representations and prototypes are an important reference for discussing and identifying potential improvements [54, 64].

2.4 Co-designing with users of local households

There is an increasing interest in studying technology in the home [131]. It is helpful to understand the internal dynamics of family life that determine the adaptation of the technologies in question [189]. Within households, social space and technological space interact in complex and often unpredictable ways. It is therefore important to prove technological concepts in practice and to explore how intended use is related to actual use.

In order to co-design with users in an ongoing and long-term manner, the approach of Living Labs became an important concept as the user participates in real usage contexts [5, 127]. Such environments include both artificial and real life contexts. While artificial labs offer a controlled environment to measure and record details regarding mock-ups and early alpha versions, real life context helps to understand how techniques are applied in practice [90]. The long-term cooperation between different stakeholders helps to create a shared understanding of the context.

Co-designing with local households delivers profound feedback from users in everyday practices and routines, and helps to brainstorm new ideas among stakeholders. Co-creation is supported by involving users in early design stages; prototypes can be validated and improved [53]. Evaluation can take place in different stances, e.g. in an artificial lab in early design stages and later on in real world contexts. Compared to single stage user involvement, a long-term perspective helps to improve the design process and enrich it with user-generated ideas, feedback from practice and mediation among various stakeholders. Returning participants provide more reflective and informed feedback regarding the design artefact [180].

The long-term involvement of interested users requires cooperative forms of articulation to stimulate exchange and use. Contrary to studies referring to the lead user theory [149], and informing a company-driven user involvement, there is a more democratically-oriented direction in line with the Scandinavian approach of PD. Such a democratic innovation involves more than simply a process democratized by the involvement of lead users [20]. Instead of focusing on innovations that have been democratized, democratizing innovation refers to alternative practices that appear in open and creative innovation milieus. New ideas and constellations evolve during long-term collaboration with different stakeholders. The users' motivation to participate is varied and implies both extrinsic and intrinsic aspects. Users are interested in obtaining and exploring new technology. However, they are interested in gathering further knowledge, obtaining support when using new technologies and exchanging experience with others [91].

2.5 Tools that support co-design activities

2.5.1 Cultural Probes

When it comes to design goal statements, designers are faced with the challenge of mediating between different perspectives. There is a design paradox regarding contradictory subgoals that refer to different discourses [50]. In order to mediate between differing expectations and needs, technical toolkits provide guidance for discussion and mediation. The user benefits from a facilitated articulation of new ideas, problems with the infrastructure, or requests for improvements.

Cultural Probes are one of the infrastructuring toolkits which empower users to reflect on existing infrastructure. Cultural Probes help to explore the user's attitudes, wishes and needs [66]. There are several variations of probes, adapted for different research contexts [27]. Some of the concepts are designed to collect structured feedback [32], to explore a new technology [102] or to stimulate feedback in a playful manner [15]. Mobile probes [99] can be used to conduct user studies more flexibly, by documenting in a mobile context.

Probes need to be designed in a way that makes them interesting and attractive to explore and which stimulates the user's attention [104]. Participants reward efforts in designing probes in the sense of the quality richness of feedback. Especially in the work context, the employee's obligation of use and time are considered as the main roadblocks. In order to successfully adapt these methods, there are also variations that render the probes more lighthearted [15] or which indeed present them as a pleasurable little extra to be enjoyed even at work [118]. Probes should be understood as self-reporting tools, supporting open and creative user feedback in their natural surroundings. Users are enabled to both, articulate directly while using an artifact in-situ and also to complete and comment the feedback.

2.5.2 Feedback Tools

The involvement of users can be initiated at the different stages of development: to identify initial ideas, to test mock-ups and also to test functional prototypes. Social technologies, including online forums, wikis and integrated feedback channels, empower users to participate remotely in different phases of design. Such distributed participation makes feedback cycles more flexible and helps to involve users from a target group, even if distributed over a wide distance. Several studies have shown the potential of online user communities [64, 168, 150]. But when PD moves beyond grasping ideas, there is the necessity to structure and organize the process and support participants with adequate tools for discussions and contributions. One direct method is to send prototypes and collect feedback via email [54]. With the rise of fast internet connections and social technologies, early mock-ups via interactive screens can be evaluated and commented online. Design concepts can be visualized in diverse forms, and users can provide feedback on the user interface and functionality [64]. The feedback of a potentially large user population helps companies to identify needs and potential improvements.

Traditional lab studies can be applied to reflect early prototypes in a structured manner. Walkthroughs, interviews and observation help to understand how users interact with the systems and also help to identify critical incidents and usability issues. But systems also need to be applied in practice, investigating how technique is adapted and incorporated in daily life and social practice [199]. Evaluation and feedback processes can be supported by methods that enable feedback directly in the context of the usage (in-situ). Self-documentation methods have to be proven as useful methods for collecting feedback and stimulating reflection. Mobile probes, for example taking photos directly in the context of use, are a suitable tool for sharing feedback with others [99]. Technology probes also support contextualized feedback by offering feedback mechanisms integrated in the technology to be explored in context of the usage [102]. Experience-sampling methods provide some kind of recall functionality that triggers and stimulates the feedback process [103].

2.5.3 Digital pen based interaction concepts

Forming ideas and discussing alternatives is a creative process in the early stages of design [111]. In this phase, a common understanding is established, accompanied by a mutual learning process. So-called boundary objects can help to mediate between the individual stakeholders [6]. When it comes to prototyping in the first design phase, sketching on paper has been proven as valuable method to visualize design ideas and discuss them in the project team [31]. Sketches can be created easily without much effort [125] and can be comfortably annotated with informal elements like comments. Large sheets of paper are most suitable for collaborative design sessions [41]. This way, technically less experienced users find it easier to contribute compared to using a computer-based model [195].

Using paper and pen has several advantages including familiarity with the materials used, and creative forms to comment and add using different colors and forms of paper. In brainstorming sessions, the paper sketches can be completed very easily by the participants. The haptic character of paper and pen has several advantages compared to screen-based solutions. The familiarity of the medium favors intuitive interaction in selecting different kinds and sizes of paper, writing annotations, accessing from different viewpoints, moving and showing others. All familiar forms of interaction enable non-expert users to be involved more easily. It is especially the intuitiveness of using pen and paper that makes pen-based interaction so interesting for participatory design. Non-expert users can begin brainstorming and sketching very quickly with only a short introduction.

Digital pen-and-paper interactions support the recognition of drawn and written content through digital transformation. Such pen-and-paper-based approaches can support users by digitalizing physical representation and triggering functionalities [41]. There are several approaches that show the potential of interactions based on pen and paper. For one thing, there are extensions of digital activities, such as the a-book [119] and the ButterflyNet [200] which supports documentation during scientific research. Other studies combine written information with audio recordings [135]. The pen also can be used for command-centric interaction, including pen-based gaming, augmentation of digital documents [76], use of gestures for editing printed documents [113], and the use of pen tapping for the retrieval of scientific citations [129]. In addition, digital pen technology also can be used as an alternative interface connected to home technology, e.g. to support the easy recording of TV shows by marking the interesting content in a magazine [12].

3 Case Studies

Processes that support co-design of home technologies

- **Chapter 4: Co-design with users of an online community** This chapter has been published as a journal paper in the International Journal on Human-Computer Studies (IJHCS), 2013: *Jan Hess; David Randall; Volkmar Pipek; Volker Wulf: Involving Users in the Wild - Participatory Product Development in and with Online Communities, in: International Journal on Human-Computer Studies (IJHCS), Vol. 71, Issue 5, Pages 570–589, 2013.*

- **Chapter 5: Co-design with users of local households** This chapter has been published as a journal paper in Entertainment Computing, 2012: *Hess, J., Ley, B., Ogonowski, C., Wan, L. and Wulf, V. (2012): Understanding and Supporting Cross-Platform Usage in the Living Room, In Entertainment Computing, Volume 3, Issue 2, May 2012, Pages 37-47.*

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- **Chapter 6: Infrastructure Probes** This chapter has been published as a paper in: Proceedings of the International Symposium of End User Development (IS EUD), 2011: *Hess, J., Doerner, C., Pipek, V., and Wiedenhoefer, T. (2011): Expressing Use: Infrastructure Probes in Professional Environments, in: Proceedings of the Third International Conference on End-user Development (IS-EUD'11), Springer-Verlag, Berlin, Heidelberg, 301-306.*

- **Chapter 7: Cross Platform Feedback Tool** This chapter has been published as a paper in: Proceedings of the International Interactive Conference on Interactive Television, 2012: *Hess, J., Wan, L., Ley, B. and Wulf, V. (2012) In-situ Everywhere: A Qualitative Feedback Infrastructure for Cross Platform Home-IT, in: Proceedings of the 10th International Interactive Conference on Interactive Television (EuroITV '12). ACM, New York, NY, USA, 75-78.*

- **Chapter 8: Involving non-expert users to reflect on processes** This chapter has been published as a journal paper in the International Journal of Cooperative Information Systems (IJCIS), 2012: *Hess, J., Reuter, C., Pipek, V. Wulf, V. (2012): Supporting End-User Articulations in Evolving Business Processes: A Case Study to Explore In-*

tuitive Notations and Interaction Designs, in: International Journal of Cooperative Information Systems (IJCIS) (ISSN: 0218-8430).

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4 Involving Users in the Wild - Participatory Product Development in and with Online Communities[1]

Abstract

In its traditional stance, Participatory Design (PD) is centred on certain work/application settings and is concerned with the involvement of representative users from these contexts. Nevertheless, current web technologies enable new forms of distributed participation which might allow PD processes to be implemented in a broader and flexible way, but may at the same time raise new issues in relation to participation. In this paper, we report on a Participatory Product Development project, using social technologies, where new issues were raised – a large population of heterogeneous and globally distributed users; a range of personal and institutional purposes, and the use of these technologies in a largely untested environment. We will reflect on insights that we gathered by through observation of and participation in a software development process driven and influenced by members of an existing online community. By means of participatory observation, analysis of the use of online tools and through semi- structured interviews we identified issues around different notions of timeliness and of process structures that are related to different roles, responsibilities and levels of experience. Our results indicate that the involvement of heterogeneous users in such a context needs to be handled carefully, for the reasons we set out. The role of user representatives acting for a broader online community can become crucial when managing heterogeneity, formulating acceptable compromises and- perhaps most crucially- dealing with different professional and 'hobbyist' worldviews. Additionally, we found that the use of standard web technologies only partly support online participation processes. PD 'in the wild' needs to be better embedded in use situations and environments (e.g. by linking discussion and design space, using feedback tools, continuous reflection of the current state of development) rather than refining participatory design as a meta-process separate from use.

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4.1 Introduction

Software development is a process which can, of course, take many forms. All of them, arguably, involve the management of different stakeholders. What is crucially at stake is the way in which disparate interests are represented, valued or otherwise discounted. In one version of the development process, one which is very different in a number of respects from more traditional, top- down or 'managerialist' methods, is that of participatory design (PD). PD has many forms and has been controversial in some ways (see e.g. Kraft and Bansler, 1994 [110]) but it would be largely uncontroversial to argue that, as a minimum, it always privileges the 'user' in some way. This may be for many reasons, including political commitment, product improvement, design efficiency, 'work design', and so on. Regardless, from this perspective, user involvement will be regarded as central in some stages of the design process e.g. when trying to understand user needs, when defining functionalities or improving usability. Again, however, whatever the merits of the perspective, its success - as with any design perspective - depends on the degrees to which methods can be deployed that meet these objectives. In the following we will explore some of these methodological considerations and assess the value of a particular approach.

For many years now, research around Participatory Design (PD) has explored various methods and tools that aim at actively involving users in (re-)design processes (Greenbaum and Kyng, 1991 [73], Bødker et al., 2009 [24], Ehn, 2008 [51], Bjoergvinsson et al., 2010 [20]). These explorations have encompassed a number of different but related issues. They include the degree to which it is possible to maintain user involvement across the whole of the design lifecycle; the problem of organisational complexity and the heterogeneity of tasks; the balancing of different stakeholders' rights and responsibilities; problems of knowledge elicitation, and so on. PD has, in sum, proven to be very flexible in its responses to a variety of challenges. In a situation where system design is less a problem for the single organisation, or even for one part of an organisation, we will suggest this flexibility will continue to be tested. It is arguably the case that several different tendencies have informed the shifts we identify. Firstly, there has been a general philosophical move away from 'objectivist' positions towards a more postmodern, engaged, approach in the social sciences (see for instance Clifford and Marcus, 1986 [38], Lassiter, 2005 [156]). For our purposes, the important aspects of this move have to do with the rejection of an over-homogenised conception of 'culture', a serious engagement with the problem of representation and a recognition of the subjectivity of the researcher (see for instance the literature on auto-ethnography). Secondly, it is becoming increasingly clear that a degree of methodological eclecticism has become more acceptable perhaps as a consequence of more interdisciplinary stances. The use of ethnographic methods as a supplement to other knowledge elicitation, or knowledge sharing, strategies (see e.g. Simonsen and Kensing, 1997 [176], Bødker et al., 2009 [24]) is but one example. Thirdly, attention has shifted towards mechanisms by which these more general philosophical and methodological considerations can be systematically applied to the design process (see the literature on co-construction). Having said all this, yet another source of analytic complexity is becoming apparent. The development of a 'digital' world means that, potentially at least, the relationship between user or consumer and producer might be changing, that users are an increasingly heterogeneous population, and that the sheer pace of change might be accelerating.

In what follows we will examine an approach to user participation in a context that reflects this new reality. Specifically, the context we examine is one where a producer organisation adopts participatory methods in partnership with an academic institution in order to solicit feedback from a heterogeneous group of users who are not members of either institution. We then assess the viability of social media as a means to deal with this kind of challenge.

Of course, use of the social media for research purposes is not new. As stated by Dittrich et al. (2002) [45] and Hagen and Robertson (2010) [78], social technologies give rise to new forms of participation 'in the wild'. Ideas, concepts and tools can be reflected on and discussed in collaborative discourses to which users from different contexts and different communities of practises can contribute. Product design development can be shifted towards the (distributed) real world contexts of users. "Participatory design is, as we see it, no longer primarily a professional issue for software developers, but has to be extended to the relationships between different user-designers, and, beyond that, between them and their clients/customers/service-seeking citizens in general." (Dittrich et al. 2002) [45]

Distributed participation, it has been suggested, can be initiated by a company in a more controlled manner from the outset, e.g. by gathering feedback concerning a web-based prototype (Fueller et al., 2006 [64]). Equally, design processes can become more responsive to user-generated modifications (Jepessen and Frederiksen, 2006 [150]). Nevertheless, and as we have indicated above, social media on their own will not address the problem of complexity (see e.g. Hendry, 2008 [83]). Methods will be required which allow for user engagement in such a way that the issues we have outlined are successfully managed. Questions of how to structure, moderate and scale the process of participation when applied to a heterogeneous and distributed user base have not yet been resolved. We therefore explore an attempt to provide more structured involvement of users in online communities in the development process of a commercial software product. The intention, as we report, was to enable the members of an online community to (co-)design new software for an internet television service and further to engage in a continuous improvement process.

4.2 The methodological foundations of PD

The importance of a reflexive approach to the 'user' has long been recognised to be an important factor in social and technological change. Some version can be found in the traditions of many different research communities including action research (see e.g. Hayes 2011 [81]), the 'Scandinavian' tradition; German work design, the postmodern turn in ethnographic research and so on (see Bannon et al. 2011 [8]). More specifically, of course, it has been applied to the design and evaluation of innovative software applications by the community of researchers glossed as 'PD'. This gloss disguises a number of different approaches. Muller and Kuhn (1993) [164], for instance, classified participatory design oriented techniques into two dimensions: time and context. Users can either be involved in the design process at an early design phase, where some form of 'requirements' are to be elicited or in a later stage, e.g. in mock-up reflections, and where a more evaluative approach is asked. Of course there is no reason in principle why involvement cannot be continuous but as Hayes pointed out (2011) [81] this is difficult to achieve in practice. The second dimension has to do with the context of user participation. That is, there is a range of options available in relation to the location of the research effort and the degree to which it might approach the naturalistic. Within this taxonomic space, a number of standard approaches are often used, including interviews, workshops and scenarios (Greenbaum and Kyng 1991 [73], Keil and Carmel, 1995 [108]). More recently, self-documentation methods have been utilised. Cultural and technological probes, for instance, are now commonplace (see Gaver, 1999 [65], Graham and Rouncefield, 2008 [72], Boehner et al., 2007 [27]), as are diary studies (e.g. Carter and Mankoff, 2005 [32], Hess and Wulf, 2009 [95]), and other similar interventionist strategies.

A further dimension has to do with the form of user participation. As Randall et al (2007:84) [141] point out, there are three questions to be answered when engaging in participatory work, and they are: 'what users?', ‘when?’ and for ‘what purpose?’ In regard to the last, Ehn (2008) [51] distinguishes between user involvement and user engagement: On the one hand, there are several participatory, design-oriented, methods that focus on participatory design or ‘design for use before use’, and in contrast there is meta-design (Fischer and Scharff, 2000 [55], Fischer and Ostwald, 2002 [58]), which focuses on a ‘design for design after design’. In the former instance, PD has attempted the ‘unattainable’ in trying to fully anticipate use before actual use. The meta-design approach, in contrast, aims to design flexibly enough that continuous adaptation will be possible. This is closely related to the concept of infrastructuring (Star and Bowker, 2002 [182], Pipek and Wulf, 2009 [170], Stevens et al. 2009 [184]). The force of this argument is twofold: the role of users extends well beyond the design and even the evaluation phase of a design project, insofar as design will envisage further appropriations over a period of time, and secondly it implicates some transformation of purpose, in that control over ’what users are for’ will be less of a matter for designers to decide. As Bødker et al. (2009) [24] have argued, users can be ‘used’ as plain informants or can actually be given the chance to participate in project groups. They describe ‘Genuine User Participation’ as a mutual learning process between designers and users. Such a mutual learning requires continuous user involvement in order to gain a shared understanding of the problems and needs. Björgvinsson et al. (2010) [20] differentiate between an innovation process that is democratized through the involvement of lead-users and an alternative practice of democratizing innovation, where issues and ideas evolve bottom-up from long-term collaborations among diverse stakeholders. They refer to their experience with Living-Labs, which allow participants to become active co-creators and users of the designed artifacts in real life contexts.

In any event, one part of Ehn’s focus is the transformation of material forces such as social media, and the way in which they might have an impact on meta- design [51]. Related to this is the recognition that multiple, and heterogeneous, users, their uses and experience is a challenge for PD (Bødker and Sundblad, 2008 [23]). It is intuitively obvious that platforms for massive participation around social software and Web 2.0 hold potential for PD. Barcellini et al. (2008) [9], for instance, describe a use-case related to open source software where interested users became engaged in different online discussions and acted as ‘boundary spanners’ between users and the developers, e.g. by bringing issues from the user space to the developer space. Hagen and Robertson (2008) [77] also highlighted the importance of social technologies as environments for remote participation early in the design phase. Contributions from community members, they suggest, bring meaning and measures to basic work done by the designer. Instead of defining a system a-priori, building blocks such as functionalities, navigation structures and themes can emerge. Even so, 'PD in the wild' using such media raises some issues, not least because users are geographically distributed and potentially anonymous.

Parallel to the developments in PD, there has been the evolution of 'community' approaches to product design. Much of this has been characterised in terms of 'living labs' but what is entailed is the placing of product prototypes with selected groups of users. The use of so-called 'lead-users' in the design process to identify new trends and demands is associated with von Hippel (1986) [149]. Lead-users are users who are aware of needs much earlier than the mass market (von Hippel, 1978 [148]). Such users can typically be found outside the boundaries of a company and are organized (or organize themselves) in so-called 'innovation communities'. More recently, and with the explicit use of social media, companies have begun to create and organise 'innovation communities' themselves to achieve firm-level objectives (West and Lakhani, 2008 [192]). Recent studies on community based innovation point out that user communities have a value for organizations, e.g. in order to identify new trends for new product features (Fueller et al., 2006 [64]). In the context of software development, Jepessen and Molin (2003) [151] observed how an online community devoted to a multi-player game was included in the co-development of new versions. Gamers spent months developing new features, which they published and made available online for others. In other works, which is related to computer-controlled synthesizer software, Jepessen and Frederiksen (2006) [150] described the unexpectedly positive reactions of a company after their commercial software product was hacked and 'modded' by users. New innovation communities have been instrumental in the development of products for, inter alia, snowboarding and cycling (Franke, 2003) [61]. 'Communities for co-design' differ from innovation communities in a way, that potentially all customers can contribute instead of selected lead-user (Piller et al., 2005) [168]. Such communities also address the creation of a new solution space instead of configuring a given product.

The development of the Web, the rise of a 'prosumption' philosophy, the progressive recognition that research of any kind involves a reflexive relationship with subjects, developing product complexity and the heterogeneity of user communities, have all generated opportunities and challenges for the design relationship. Nevertheless, there are, we would suggest, few studies which have fully explored the positive and negative features of online 'user communities' as a systematic vehicle for participatory product (re-)design in non- work contexts (Jepessen and Molin, 2003 [151], Jepessen and Frederiksen, 2006 [150]). In the following, we will explore a specific application domain for leisure use. In our previous work we have already described how an existing online community could be a valuable basis for such PD processes (Hess et al., 2008 [86]). However, we left many questions unanswered, the most important of which have to do with whether the involvement of online communities entails explicit methodologies and strategies or can evolve organically, the degree to which heterogeneity leads to a vagueness of role and purpose, and whether these strategies - if they exist - can be successful in the long-term. We will examine these issues through data collected from a number of sources which we will describe below.

4.3 Community driven development

With the growth of new social technologies, such as blogs and wikis, new forms of online and remote participation can be realized. Much existing research has looked in a fairly general way at the similarities and differences between face-to-face and online communities (see e.g. Wellman and Haythornthwaite, 2008 [191], Rainie and Wellman, 2012 [171]). Not for the first time, these developments have been accompanied by an emphasis on positive effects and by mild forms of technological determinism (Wagner and Prasarnphanich, 2007 [190], Mansour et al, 2009 [161]). It is, we argue, important that a nuanced picture of the relationship between new technology; new communities and new design spaces is obtained. We will report on one such project in order to identify the factors that best explain the trajectories we observed in the participatory process. The concept of a community driven development (CDD) is close related to a 'community for co-design' (Piller et al., 2005 [168]). Users, in this view, not necessarily lead-users, can contribute in the development process by using online tools and social technologies. Additionally, participants of a community driven development project can have strong influence in the design and decision process. Every participant from the online community can, in principle, contribute with own ideas, participate in discussion, can access design decisions from the steering committee and reflect on them. Representatives from the user side and from the company side cooperate intensively in a steering committee to identify requirements and decide together. Members of the steering committee moderate discussions within a broader online community, collect requirements, reflect decisions and fulfil the role of a bridge between users and developer.

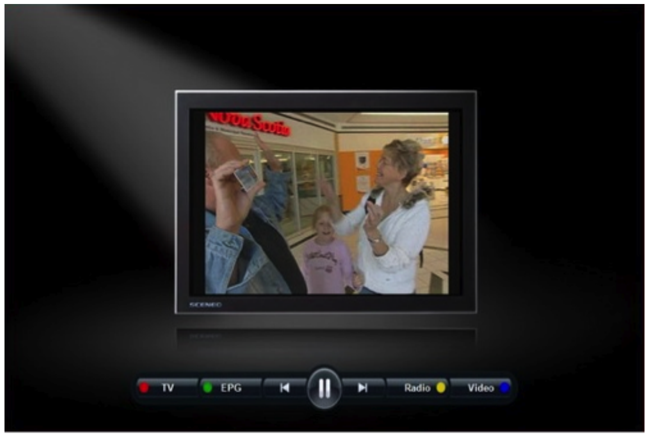

Figure 1: Image of the start screen of the new media centre software

4.3.1 Project context

The project involved a collaboration between academic partners from a German university and ‘Omega’– an SME that historically has focused on the development of tax and finance software for households and SMEs. Several years ago Omega decided to invest in new product fields and established a new business division for this purpose. This subdivision of Omega develops software that connects and integrates new PC functionalities into TV environments. The main product of Omega is a media centre software that was first sold in August 2004. This media centre integrates several kinds of media, including images, music, video, the Internet, television, and also presents them in a central interface (see figure 1 for a screenshot). The core of the software was externally developed in the United States. Omega customized the software, added basic plug-ins and sold it on the German market. The television module, as an important part of the software, was developed externally by another SME. The software was intended to provide functionalities over and above those designed by Microsoft with their Media Centre Edition. It, for instance, supported a broader range of digital television cards in the early days.

Omega has been involved in a continuous improvement process for a period of about three years. Three versions were released during this time. In 2007 Omega lost the rights to continue selling the software core and, because it was determined that the existing functionalities did not adequately reflect user needs, decided on a complete redesign. The company already had a very active online support on their website, with a total registration of ca. 20.000 members. Users who used the software for the first time had often asked for help with the installation and configuration. Some users had gained quite a lot of experience over time and participated regularly, on a voluntary basis, in helping others and discussing software issues. Omega decided to enlist some of these users as online-moderators, and also provided a separate forum for them. Within the moderator forum, Omega posted news about updates and further developments here first. Moderation became a very significant way of filtering the large number of messages the company received, since they were able to collate and organise various comments into coherent themes and provide succinct summaries of pressing problems. Omega also invited the moderators to face-to-face meetings, where new developments and features were discussed. This existing structure was the departure point for the more structured process we call community driven development. A steering committee (SC) was formed as the main coordination and decision body, and consisted of representatives from the online community, the company and the external development agents. The online community, or User Parliament (UP) as it became known, in contrast had no formal structure. About 70 members of the original community applied for a position in this new body.

The university team had collaborated with Omega for several years previously in different research projects and one author of this paper has been involved as a community manager and therefore was familiar with Omega's products and knew the employees quite well. The university team had a broadly evaluative role, observing online and face-to-face interactions, conducting interviews with employees within the company and with users of the online community, participating in group discussions (forum and telephone Telco) and monitoring online activities (in forum and wiki).

Members of the SC participated actively in the discussions which took place in the UP, and used these discussions to collect requirements, ideas and improvements regarding the planned product. In weekly telephone calls members of SC discussed the input from the UP. In these group discussions representatives from Omega and from the community specified functional scope and priorities. Results of that decision processes were made public in a wiki system so that all members involved in the project were able to see the current state of the requirement document. The wiki was accessible and made public on the Omega website, and users were able to modify or add entries, and to discuss entries in the forum in case aspects should be improved or modified.

4.3.2 Methods

Having seen the potential of the CDD approach, we decided to accompany this process in a systematic manner by adopting a Grounded Theory approach (Glaser and Strauss, 1967 [69]). Grounded theory has had a long, if somewhat controversial career (involving as it has more than one version- see e.g. Strauss and Corbin [186], Glaser, 1992 [70], Bryant and Charmaz, 2007 [30]), but can be roughly summarised as an inductive procedure whereby the results of single case studies, or ethnographic work, can be progressively coded so as to provide useful generalisations founded in data, rather than the abstract theoretical constructs which were associated with the social sciences at the time of its inception. More importantly, it prescribes an analytic approach through which categories or concepts can 'emerge' rather than be forced into theoretical structures. It has subsequently become a popular analytic technique in design- related activities (see e.g. Fitzpatrick, 2003 [63]). We should note here that grounded theory presupposes no particular method and it has been argued by some of its proponents to be equally valuable regardless of whether qualitative or quantitative methods are being applied. Depending on the kind of approach advocated, various coding schema have been recommended (see e.g Strauss and Corbin, 1998 [186]), although we should note that early versions of grounded theory (Glaser and Strauss) contain no reference to 'types' of coding. At the same time, grounded theory was never intended to be a mechanistic device. Strauss and Corbin (1998:8) [186] comment that "[recommended procedures] never will develop if researchers focus solely on the procedures presented in this text and apply them in a rote manner. We want readers to understand what we say, to understand why they are using certain activities, and to do so flexibly and creatively." Thus, while we applied systematic coding schema to our understanding of users' requirements for the system being developed (not described here), we did not do so with the same systematicity when analysing the processes, which underpinned their collection. For the purposes we outline below, open coding formed part of the process, axial and selective coding rather less so.

Our own approach was to adopt a 'mixed method' view, such that we used more than one way of obtaining data. The most important qualitative work consisted of semi-structured interviews. Six participants from the company, four elected representatives from the SC, and four users in the UP were interviewed at least twice, and each interview lasted around 30 minutes. Representatives from each instance were interviewed in two phases – once at the beginning of the project and again at the end, when the first alpha version had been released. The members of Omega and the members of the SC were interviewed in person rather than in the Omega office or at the workshops. Members of the UP were interviewed by phone. The interviews were audio recorded, transcripted and analysed afterwards. Additionally, we had done some quantitative analyses in order to understand the intensity of participation in the online forum (count of users, entries, writing intensity over time etc.). In the second phase of the project we also made use of a feedback tool that was integrated into the beta version. The beta version was available as a free download for all interested users via Omega's website. The plug-in enabled all users of this version to rate different aspects of the software including functionality, usability and design during use-time. Results from that feedback module helped to understand general satisfaction with the product. In total, our data collection involved more than one year of elapsed time.

4.3.3 Process

The schedule of the project can be separated into three major phases (see Figure 2). Internal planning (I) started around 5 months before users got actively involved in the discussions. In order to find users who were interested in participating in such a design process, the concept was promoted via an 'invitation' on different online channels. Several IT news providers published a press release and the weekly newsletter addressed some thousands of registered users from Omega. The invitation included basic information regarding the community driven development with the goal to develop a new media centre application. Users who wanted to participate in the design process could apply via an online form for membership in the Parliament.

The cooperation (second phase in figure 2) started with the official kick-off workshop, where members of the SC met in person. In that two-day workshop, users, employees of Omega and external developers met and discussed technical conditions and the overall agenda for the project. Some days later a technical preview was released and users started to discuss this in the forum. The technical preview provided a first impression that was intended to stimulate discussion and help the users to be more creative. After four months the third phase started with the release of the first alpha version. This phase took about four months as well. While phase II focused on discussing and adapting the requirements, phase III focused on the improvements to the software modules. Five alpha versions and one beta version were released in the last phase. After the final version was released, the CDD was to be continued as an on-going process to develop new plug-ins

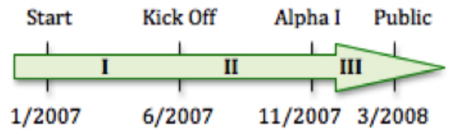

Figure 2: timeline of the whole development process

for the basic system.

4.3.4 Participants

The 70 users who applied for a position in the User Parliament (From the ca. 20.000 registered users of the original online community) were all accepted as participants in the project. In the online application form, users specified their media centre systems and were asked to comment on their motives for participating. Participation here meant that these users had access to a separate forum, where they could write down ideas and requirements, and discuss these aspects with others.

The members of the SC were selected from the Omega team and the moderators of the forum. The moderators were nine private users who worked on a voluntary basis. Omega had been cooperating with these users for a long time. In the internal forum, moderators and employees of Omega discussed the applicants for the committee. The moderators and the Omega team agreed on four additional users, who had already attained the status of moderator and were selected for their overall technical competence and ability to lead discussions. The election process was not a classical democratic process in the sense of a poll, but rather a discussion where all moderators and the whole Omega team were in mutual agreement.

The core team of Omega includes 7 in-house employees working for that division, their roles are summarised in table 1. The SC was supplemented with two members of Omega and an external developer, who was held responsible for the development (see figure 3). The employees from Omega held positions for community support and quality control ("Omega Support") as well as product management ("Omega Manager"). Both employees were chosen because they had already been very involved with the community before this project.

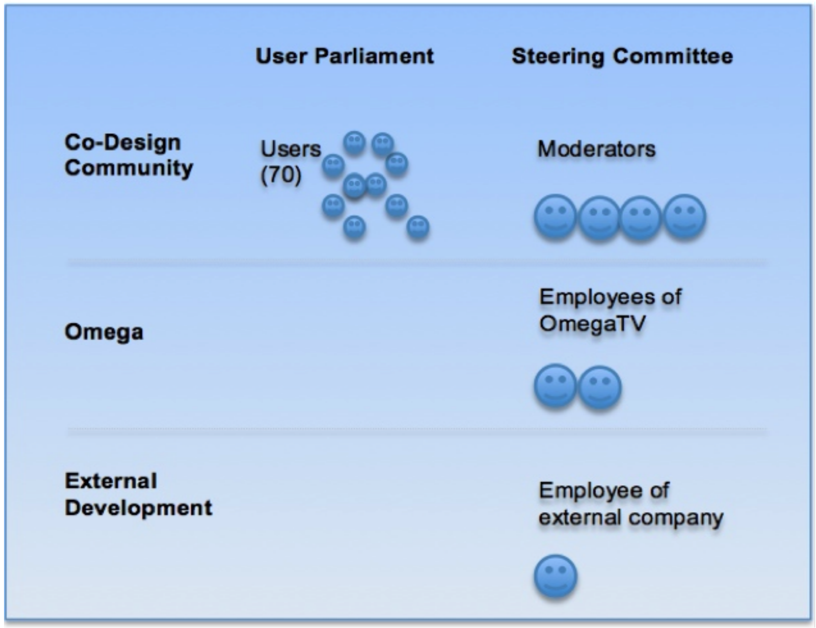

Figure 3: Staffing of the Steering Committee

4.4 Empirical results

Our aim in this study is explicitly evaluative. We were and we are interested in the changes that have shaped the evolution of a particular participatory strategy, one which we have termed CDD, and in identifying the factors which mitigated elements of success and failure. Our aim is to reflect on the process in order to provide some ideas about how community development projects of this kind can be made effective. PD processes 'in the wild' are still not common and our results suggest that various imbalances in the timing and process structure mean that the community driven approach becomes difficult at some points. Here, we want to summarize the most relevant reasons for these phenomena and then present suggestions for the further improvement of such projects.

4.4.1 Role of the user, risk and motivation

In the first interview, the "Omega Manager", as the product manager, summarised the selection process of the SC in the following way:

Omega Manager: "In principal we discussed the applications

> within the team. 'Who is important from the past? Who contributed to the forum quite well?' Most of them we already knew. [User1] ... and [User2] ... we had already known for a long time. Those two, we knew that they had their feet on the ground and were stable candidates ... [User2] is important because he has family and two children ... where the child also uses such a device. [User1] – a woman and a little girl, who also deal with media, and an extreme amount of music, as [User1] is an extreme music fan. These were already criteria. ... [User3] as a critical one who kept putting salt on the wound. [User4] because he also contributes very well to the forum. And then of course, ["Omega External Developer"] as project leader, [employee of the external company and responsible for the development] and also two more from our team. That is ["Omega Support"] and I. ["Omega Support"] because he has the technical expertise and I ["Omega Manager"], because I have to keep the chaos together."

What is interesting about this, of course, is that there is an early recognition that more than just technical skills will be required. User representatives, who are already known to the company, seem to have particular qualities. Some parts of the criteria used have to do with user experiences that are assumed to be relevant, such as the consumption of music. A second part has to do with family structures and the desire to ensure that the behaviour of children is somehow incorporated, and a third element has to do with the personal qualities of the representatives, including that they 'have their feet on the ground' and are able to take and express a critical view. That is, 'representativeness' on the part of the user representatives, or moderators, is construed in a number of different ways. A further feature of this is the ability of moderators to act as effective 'boundary-spanners'. As boundary-spanners between the company and the customer's world, moderators contribute on a voluntary base and are more closely connected to the staff of Omega. They normally had historical connections to the company and thus were already known:

> Omega Spokesman "... the moderators are an important link to the community which also results in regular meetings and we also make efforts that the knowledge [of the moderators] is close to that of the company. That means ... when it is cracking somewhere they can give notice and can say 'there is a problem, you have to comment on it instantly.' Because ... due to the

> size of the forum we have no longer review over all the things that happen."

Omega had already developed three versions of the media centre. It was apparent that there was some gap between user expectations and the technical implementations. Implemented features did not seem to reflect what users wanted and needed. This gap was constituted in two ways. Firstly, and as one employee mentioned, users did not always understand how systems were implemented in practice. Conversely, and arguably more importantly, very few representatives of the company, or of the external developers, had ever actually used the implemented system. Therefore, in the new development the involvement of the users was seen as an 'essential' and 'inevitable development'. Before the community project started, user needs had been informally (and subjectively) analysed by the product manager, noting comments and suggestions made by users in the forum. The product manager had then raised new ideas for features in internal team meetings. Within these team meetings further development steps were discussed and decided. In the interviews however, employees mentioned that this form of decision-making was not always the best, because often the priorities were set on the wrong features.

> Omega Manager "... ideas from the users were picked up and critically reflected again and again and some also were realized. But even nice examples, things that we implemented, were rated as 'shitty'. So we made things where we recognized later on, that actually no one needs it."

In other words, even if Omega took user feedback into consideration in the early days, decisions and priorities did not adequately reflect a broader audience. By setting up the community driven project, Omega focussed on a strong user involvement with the goal of good acceptance of the product and its features. Consumers' experience of the every-day use of the products could in principle provide perspectives the Omega staff were not familiar with before and priorities could reflect a larger audience. We interviewed employees about their opinion of the new user driven process and identified quite different motivations, perceptions of risk, and fears. O6 as head of that subdivision of Omega and also as head of marketing had initiated and pushed the approach as an important and necessary way to co-develop with users and meet their needs. The internal developer also was open-minded and highlighted the potential of user involvement:

> Omega Developer 'I think about it well in principle, because if you are deeply involved in development you often go round in circles. ... One have it's own view and that's not necessarily the right thing. ... There are chances that are you closer to the market. You can get an overview about the needs of the end-user.'

However, the product manager feared that users might have too high and too naive expectations and might therefore be frustrated if their ideas could not be considered.

> Omega Manager "I am very sceptical because there is the possibility of. too many cooks spoiling the broth. ... It can be ... an extremely high administrative effort and frustration on the user's side can also be very high if we do not realize his or her intended ideas."

Apart from this observation a problem mentioned by four of the employees was the time factor. This kind of system exists in a rapidly evolving marketplace and some employees were mindful of that fact, especially given that internal deadlines were known by employees:

> Omega Spokesman "After all, there is a certain kind of time pressure. We are not talking about casual get-togethers, meetings which aren't very goal-oriented. We always have to keep in mind that after all, this is a trial to produce commercial software, which also has to sell."

In such a changing environment, there was considerable uncertainty on the part of the company. The very substantial investment of time and resources would not necessarily pay off. In contrast, from the users' point of view, there were hardly any risks. A successful project could supply them with software that would be closer to their needs, but even a failure would not bring about any disadvantages apart from the loss of time. Most users participated in the project because they were given the opportunity to influence the development process by bringing in their own opinions and ideas. Some users already knew from the beginning which particular functions they wanted to realize, while others were concerned with more general factors such as stability and usability. Several participants enjoyed the cooperation between users and developers. No user had financial reasons for his/her contributions, as all worked on a voluntary basis. Moderators explained their involvement with the fact that the engagement with the software itself was a hobby and therefore fun.

> User Steering Committee: "It is just a big interest, it's a hobby, my main hobby HTPC [Home Theatre PC], it's just a lot of fun. It is a leisure activity, a balance."

4.4.2 Intensity of participation

We are not the first to report on a varying degree of user participation in PD projects. In figure 4 the most important quantitative results regarding the intensity of participation are described. Users end to lose interest when more technical considerations come to the fore; there are sometimes conflicts between user interests and those of management or other commercial interests, and other considerations sometimes intervene in what can be a time- consuming process. Although there is sample data about online forums in other contexts (Jepessen and Molin, 2003 [151]), until now there has been none that describes the trajectory of involvement in a CDD of the kind we describe. It is not entirely surprising to report that highest levels of participation were in the early project stages. There was a rapid tail of involvement on the part of user representatives in the SC and users in the wider UP group after the 1st month. The decline in contributions by employees was less marked but nevertheless significant. About 2000 entries were written in the first three weeks, and several of these were rather long. At the end of the 4th month, the first alpha version was released which prompted a resurgence of interest.

Results from figure 4 show the number of thread entries in the forum from most active users (referenced as 'user 1' to 'user 4'), from the moderators (users in the steering committee, referenced as 'moderator 1' to 'moderator 4') and employees in the steering committee ('employee 1' and 'employee 2'). The seventh member of the steering committee (employee 3) is not included in the figure because he contributed only five entries in forum discussion. Results show a high involvement of the most active users and employees in forum discussion. In general, users and moderators contributed very actively. That is in line with the approach of CDD, where users bring in their ideas and discuss them with moderators and employees. In order to show the changing intensity of participation over time, we distinguish between three phases: phase I, the first month: the initial phase with high user involvement in bringing in feature requests and discussing them with others, phase II: the pre-alpha time span, where intensity of participation

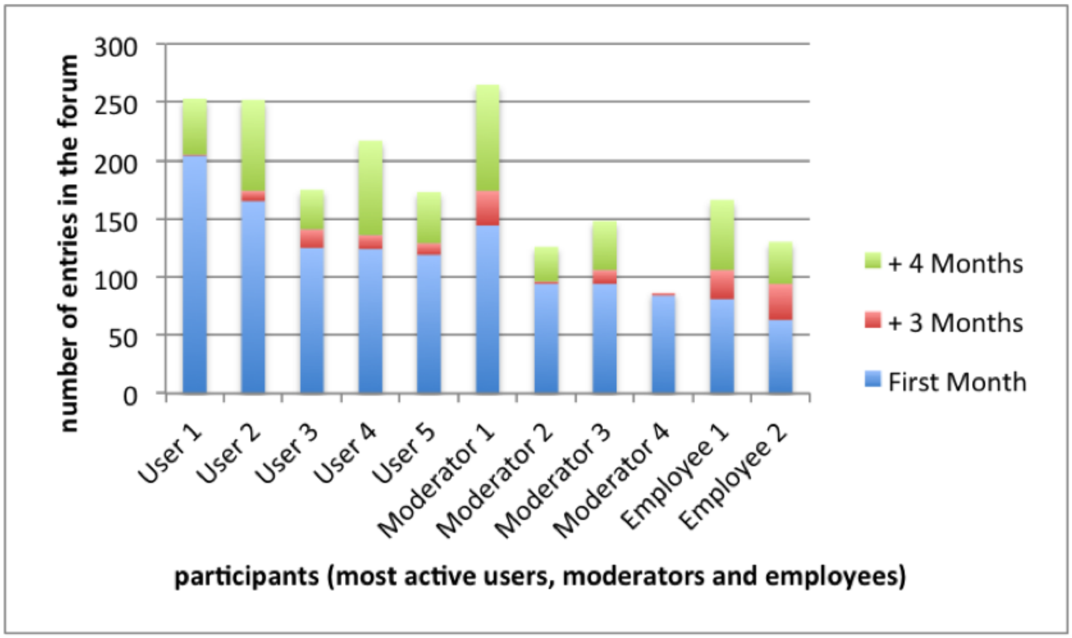

Figure 4: Intensity of participatione

slowed down significantly while users were waiting for the first alpha version and phase III: the post-alpha time span, where participation increased after the first alpha version was released. Results show a strong difference between these three time periods, with highest rate of participation in the first month. Feature requests were posted and discussed intensively. But after one month, the participation in the forum slowed right down. Users were waiting for the first alpha version and asked for further information regarding the state of development. As soon as the alpha version was released after four month, users became strongly active again. Several alpha versions were released in the third phase, what helped to stimulate discussion and participation.

With reference to overall participation, only 49 users out of 70 who applied for the project took part in the forum discussions. After the first alpha version was released, the UP was opened up for all interested users. 141 additional users then joined the discussions, although most of them only reported software errors. From this group around 30 persons participated regularly and also made suggestions for improvements. Although every alpha version was downloaded about 500 times, the number of reactions decreased heavily from the first to the fifth version. Most reactions related to the later versions were regarding technical problems.

The moderators within the SC had to fulfil an ambitious role. In their role as user representatives they needed to scan all the new forum entries, communicate and discuss user's needs and requirements, take part in weekly phone conferences, answer questions from users and defend decisions made in the steering board. Difficulties occurred especially at the beginning of the project when all new entries needed to be scanned and requirements needed to be summarized. Weekly Teleconferences often took several hours. Moderators were nevertheless strongly active and very engaged in first months. A crucial point in the project was the release of the first alpha version. Moderators wanted to wait because some basic features promised in the requirement list were not implemented. "Omega Marketing" on the other hand enforced the release because of budget reasons for the project. Then, as predicted by the moderators, atmosphere became strained after the first release, users in the online community complained about missing features. Moderators reduced engagement, and one of them dropped the project completely. This meant that the balance of the SC had altered, with user representatives no longer the majority. Dissension was one reason for this, but also other job and personal commitments meant that user representatives could not guarantee availability. Members of Omega were not happy with this more 'occasional' commitment by user representatives:

> Omega Support "That is a problem ... actually we have ... four members in the Committee ... among those only three are still active, as one has dropped out somehow. At first he was ill and now there is something else again ... and even of the three other persons, one of them is working, which means he is an employee who is travelling all day, while the other one is a self-employed person who owns a gas station and has a bit more time. Well, and this does not make it easier."

This shows another problem with user participation. Firstly, and most obviously, a certain kind of participation decrease seemed to occur at some point, as indeed it does in some other cases of PD work. Just as significantly, if representativeness was an original consideration, the fact that there was a considerable imbalance in the degree of participation by different individuals is also problematic. Of particular interest, and we will refer to this again, is the very low level of participation by the developer.

4.4.3 Decision process

Members of the SC had to decide which functionalities had to be considered and which not. Reducing the amount of ideas and opinions from the UP to a clear list of decisions was a major problem. Especially at the beginning it was extremely difficult to keep up with the speed of input. Some threads were quite long, over three or four pages. While reflecting on the process afterwards with members of the SC, one of them mentioned problems in scanning all the new entries, which caused 'management' difficulties:

> Omega Marketing: "The SC is has weekly discussions via phone conference. ... These meetings last around two hours, that means they are relatively intense, [the meeting] results in decisions for the requirement document, transferred in the Wikipedia structure. I think we can be more than happy at this point in the project, we hadn't expected so much involvement from the side of the user, especially regarding to the level of details of their suggestions. There are some difficulties with the large amount of ideas from the UP, these 2000 posts, to discuss this once a week per phone here in the SC. Because of the huge amount it is really difficult to keep every detail in mind, so there is a need for improvement."

Discussions within the SC mainly took place during the weekly telephone conferences, even though a separate online forum existed for them. But although most of the weekly conference calls lasted about two hours, some people were not able to make their voices heard. Discussions were further complicated by the fact that nobody in the SC wanted to be responsible for decisions in the beginning; thus, discussions were frequent, but with quite different levels of engagement. Additionally, no member of the SC wanted to be responsible for writing the entries for the wiki system. The product manager took on this role but, as a result, it sometimes took a long time before decisions were published:

> Omega Manager: "The moderation and the discussion were difficult in part. ... That was extremely difficult, because one falls into such a flood of words ... there is one who talks a lot and then perhaps a second one and then two people spoke 80% of time, and the two others not at all ... or all the others said nothing. That's a pity and also not terribly constructive. It was getting better in between, but by the end it was definitely getting worse again."

While conducting the feedback interviews we asked how each participant influenced the decision process. We identified the product manager as the leading figure in providing improvements and suggestions, which were accepted thereafter. He was able to express his ideas to the users in a very concise and convincing way, so that the majority followed his ideas. The product manager himself mentioned that it was easy for him to control the process as described in the following quote:

> Omega Manager: "... to tell you the truth ... it was easy to control the process ... at least in part. That means if I posted things ... they were accepted 100% of the time. In comparison to the typical user I ... had a coherent concept ... therefore it was accepted by the community ... I was part of that community and therefore had the right to do so."

Such strong involvement by one employee also created some fears by members in the UP. In the interview one of them reflected that his own choices were perceived to be of less value. He mentioned that while users can bring in suggestions they may even have less influence on the decision-making process. Although this strong engagement of Omega was not planned at the beginning, a member of the Omega team and two users both agreed that if the product manager had not participated in the creative process, there would not have been enough coherent ideas. "Omega Manager" was able to summarize previously gathered knowledge in a structured and consistent manner in comparison to most of the SC users.

> User: "The central committee got a lot of critique, from my point of view often wrongfully. ... Yes, people such as "Omega Manager" participated frequently, and also made a lot of suggestions. From my point of view he made the best suggestions. So yes, it was good involvement. A lot of stimulation, and suggestions, which were also discussed intensively. They [Omega] played a major role."

The principles that guided the relationship between the SC and the UP were that members of the SC were to post responses to the needs and demands of the UP on a Wiki after they had been discussed in the SC. That is, there should have been clear and unambiguous feedback. In the event, this proved difficult to do. This was largely a product of an overall lack of consistency in members' motivations and a lack of clear policy guidelines as to what kinds of intervention were permissible. At one point, it became clear that there was a caucus involving the developers and one user representative, where meetings took place 'offline'- that is, without participation by others. This generated considerable frustration on the part of others. They expressed reservations with this behaviour and stressed their commitment to representation:

> Omega Manager: "... it quickly became clear that their own interests were being pushed through – to some extent in a very unpleasant manner, that things were routed around the Steering Committee. ... Things that were discussed with the developer by some members. ... Things, which were never discussed in the Steering Committee this way."

4.4.4 Organisation efforts

After the first month of the project had gone by, the rate of participation had slowed down considerably. The members of the User Parliament reported that they expected new and regular information concerning the current state of development. This feeling increased when the first alpha version was delayed again and again. Users wanted to see some forthcoming developments and wanted to discuss visual things rather than the description in the wiki. One user in the UP summarized this atmosphere as follows:

> User: "I was hoping for faster and newer material. Something much faster should have been implemented to keep the boiler steaming. Always feeding in so that people have something to talk about."

This delay was related to the high development effort needed for the basic framework. Since the architecture was developed from scratch, it was not possible to show any functional prototype in the first few months. The developers focused their work on the technical framework, hardware control, flexibility and extensibility for plug-ins. On the other hand users often focused on visual aspects or only on some special details of the whole solution. That is, there was a significant mismatch between what developers and users considered 'development' to be. It became clear that there was a gap between the current state of the basic development (nothing to show) and the desire of the users to discuss at least some interface elements. Because there was no clear separation, CDD became difficult at this stage.

> Omega Developer: "... we had to implement the basic work first, to realize such a large framework ... That took too much

> time and actually resulted in frustration, because there was nothing optical to see. ... But the problem is that our development things are behind and there is nothing to see, and that is hard to communicate. That leads to frustration, because they think 'On what do they work at all? Why does nothing happen?' That is normal in software development, but to communicate that or to make it comprehensible to an outsider is, I think, nearly impossible."

The aspect of organizing and moderating the project in a structured manner over the entire time was crucial. A lack of communication was one of the most criticized aspects by all interviewed participants. The members of the community did not feel informed well enough by the members of the steering committee. But even the user representatives within the SC felt partly uninformed by Omega. They wanted to have the same access to information as the representatives from Omega, as expressed in the following quote.

> User Steering Committee: "I recognize an extreme communication problem. Already in their contact to us. ... When I say 'User Driven Development, I have a Steering Committee that controls the development.' Then I have to post essential things. I also have to trust the people. Perhaps I have to collect a written statement before, no idea, a confidentiality undertaking, however, but then I have to talk straight, because we are sacrificing our free time, but actually know nothing about what's going on."

This is not to stay that all the problems stemmed from the company. Rather, they stemmed from the lack of a common understanding of what the roles, responsibilities and practical demands of each participant might be. Because Omega outsourced the development tasks to a small external company with the necessary expertise in that field, information flow was crucial. The developer from the external company was expected to participate in the steering committee and also in the online forum from time to time in order to inform users about the current development process. But instead of discussing, or at least informing users, the developer focused on the implementation of basic modules with reference to the requirements document. The developer took part in the Telco's of the SC, but with only five postings over the whole project, the developer avoided participation in the online community forum. One of the employees mentioned this as the biggest problem.

> Omega Support: "... the development manager, [Omega External Developer], doesn't care about it. That is the biggest problem, because he could have said the most to some of the points. He could for example have said 'I cannot realize that in that time.' Because he is the developer, he could have estimated the time needed, if it was realizable at all. One could write one sentence, so that the people get a feedback at least."

4.4.5 Tools and structuring

Many of the participants did not have any experience in developing software and in structuring the process. From time to time, the users' unstructured approach to procedure was a problem. Instead of neither reading nor referring to previously posted inputs, the users posted their feedback in new threads of the forum. Therefore, threads about the same topic sometimes ran simultaneously. Instead of focusing on the general feature set, users began discussing the interface and the screen design. This does not mean that there were no useful ideas being generated, for there were, but the problem had to do with the company's general orientation to the need for structure, and users' broad indifference to it.

> User: "Sometimes ... users had less experience ... in structuring the whole .... And then everything went haywire ... However, there were surprising moments again and again where I thought 'cool idea'. Somebody made this half-baked suggestion and three people polished it up and at some point it turned out to be a very good idea. That happened again and again."

The users in the UP produced valuable suggestions but in an unstructured and occasionally chaotic way. Brainstorming, rather than any specific problem and solution orientation, seemed to be the default method of working. Different threads on the same topic were active simultaneously; the entries in one thread jumped between different topics, topics already decided upon were discussed repeatedly. Active members in the UP read new entries continuously every day. They reflected on the discussion platform positively, and argued in the interviews that they knew what was discussed and what not. But they also stated that theirs was an insider view – for other less active participants, it was probably more difficult to follow the whole discussion. After looking at summaries on the feedback we received from members in the UP, we saw that most of them were satisfied with the current tools and the unstructured process of the forum discussion, as e.g. described in the following passage.

> User: "That is normal; this is the sense of a discussion which has brainstorming character. One just spits it out first and sorts it out afterwards. It has the risk, of course, that there is a lot of trash on the table, but better some trash to select the really good things from, than being forced to only express sophisticated things, and no one dares to say anything. So it is ok that you have different threads with different topics, that suddenly the topic is changing within a thread, that one starts to discuss about a module and after all ends up at the interface concept and so on. You cannot avoid that."

If the forum was sporadically useful, the use of the wiki system was more problematic. The decisions of the steering committee were summarized there in the form of a central requirement specification to enable every user to inform himself/herself about the current status. Although the wiki system was accessed 120,000 times, references and discussions related to it were rare. In contrast, when the same topic was posted in the forum, discussion started immediately. So there clearly was a gap in connecting the forum with the wiki. The users explained their behaviour by referring to the lack of notifications when new entries were written in the wiki. In fact, the wiki system had a change log, but the requirement specifications were written down only in one document so that the participants had to search the entire file when they wanted to find new information. The following quotation from a user highlights the problematic aspect there:

> User: "… not only saying 'yes, it's all in the wiki'. It is not possible to read [the whole wiki file] completely each week, only to check what's new. A small extract, a list with the to-do's and so forth, would have been very helpful."

Also due to the delayed documentation process from members from the SC, many users avoided the wiki system and relied only on the forum. However, members in the SC did not use the forum for the announcement of decisions because they thought it should be done in the wiki system. Moderators as representatives of the users complained about that circumstance, but also mentioned the missing link between forum and wiki. One of the moderators summarized the use of the wiki as problematic: Moderator: "I have to say it to the user parliament, they have not always checked [the wiki], but maybe it's because of the missing interconnection. I mean that [the wiki] will be reached in a complete different place. One should post a link to the wiki at the end of a thread."

The issue with the unrelated discussion (forum) and specification (wiki) area especially became visible after the release of the first alpha version. Users expressed some dissatisfaction over the fact that their own suggestions were not considered in the prototype. Some of them said that the decisions of the SC and consequently the implementation did not mirror the participants' opinions. What was striking about some of these complaints was that they reflected decisions made months before and published on the Wiki. The product manager mentioned this fact:

> Omega Manager: "Nobody wanted to make the effort to sit down and read that thoroughly. I asked every now and then and the answer was always 'Yes - everything is fine'; and then, when the first version was published, all the prophecies of doom came true".

4.4.6 User satisfaction

The first alpha version of the new Omega software saw basic functionalities including television, radio, EPG and video library implemented. All interested users, even those who were not involved in the previous participation process, were able to download the alpha and subsequent beta versions for free. The release was advertised in the press and many new participants joined the discussion in the public forum.

In order to receive feedback from the whole community, a feedback plug-in was integrated into the Omega prototype. Due to the limited input capabilities of the remote control, a very fast and easy to use feedback option was chosen. After the fifth start of each software module a pop-up window appeared. Within the pop-up window the user could rate each module, e.g. the TV module, on a scale. Each module could be rated in three different categories including 'functionality', 'usability' and 'design'. Every category could be ranked on a scale from 'very good', 'okay', and 'sufficient' to 'bad' as a clear statement of dissatisfaction. This approach distracted the user from the on-going media selection and the consumption for only a short time. If the user did not want to participate in the voting s/he could cancel the process easily. The ratings were automatically stored on the server and the results of the survey could be displayed in real-time. Feedback that was generated this way, which helped staff members to get an overview of general user satisfaction for each SW module. The results are summarised in figures 5, 6, 7, 8, 9.

The feedback module was accepted quite well. Many users who did not participate in the previous discussion process, rated the modules that way. After a seven-week long field trial, 707 users rated the TV module (see figure 9). In contrast, only 35 people rated the image module (see figure 5). Such a difference immediately provides broad evidence as to patterns of system use. The TV module, not unexpectedly, was the most important part of the media centre and received feedback at the highest frequency.

To sum up our findings, the results of the feedback plug-in gave a relatively positive overall picture. ‘Design’, ‘functionality’ and ‘usability’ for all modules were rated at least by two thirds of the users as ‘very good’ or ‘okay’. Even though the results could only reflect an initial tendency, it seemed that the majority was satisfied with the first results. At the same time it became clear that some modules performed better than others. The EPG module (see figure 6) was rated quite well compared to the image (see figure 5) and music modules (see figure 8). The functionality and usability of the image module (17.14% and 14.29% ‘bad’) and the usability of the TV module (12.73% ‘bad’) received the most negative feedback. The results concerning the music module showed that there was room for improvement in all three categories of functionality, usability and design (10.57%, 13.01% and 9,76% ‘bad’).

More interestingly, previously uninvolved users were more enthusiastic about the first software release than the previously active participants. While users in the UP partly reacted with frustration for the reasons given above, the users in the public forum were appreciably more enthusiastic. Many aspects of the software were praised and the overall impression seemed to be positive. After the heated discussions in the UP forum slowed down, the process ran more smoothly in the forthcoming cooperation. Smaller improvements and suggestions were incrementally implemented in the software. Omega published five alpha versions and one beta version this way. The comments of the users during the final interviews also underlined a positive overall reflection. Users were pleased with the results even when they also pointed to problems in the previous communication and development process: User: “With the result quite satisfied, with the process of work not that much to tell the truth. .... I still believe that everything went wrong a bit, such as the staffing of the Steering Committee that did not meet my expectations partly, and still also the communication.”

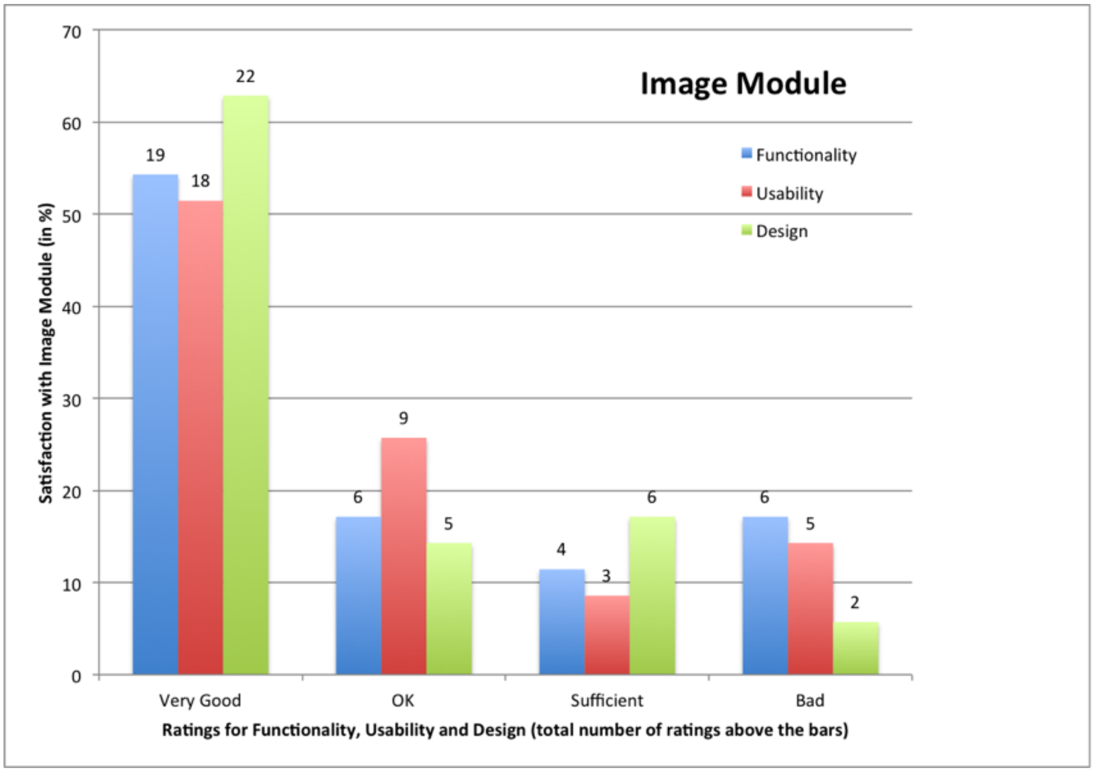

Figure 5: Rating Image-Module

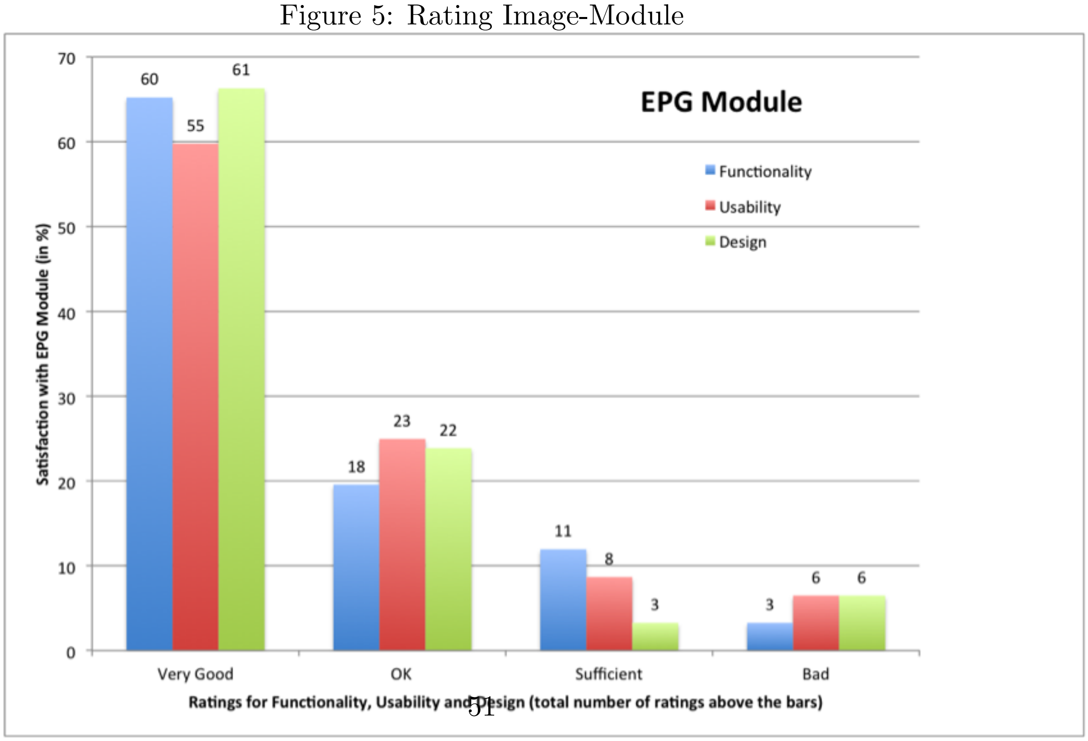

Figure 6: Rating EPG-Module / Percent (Number of Votes)

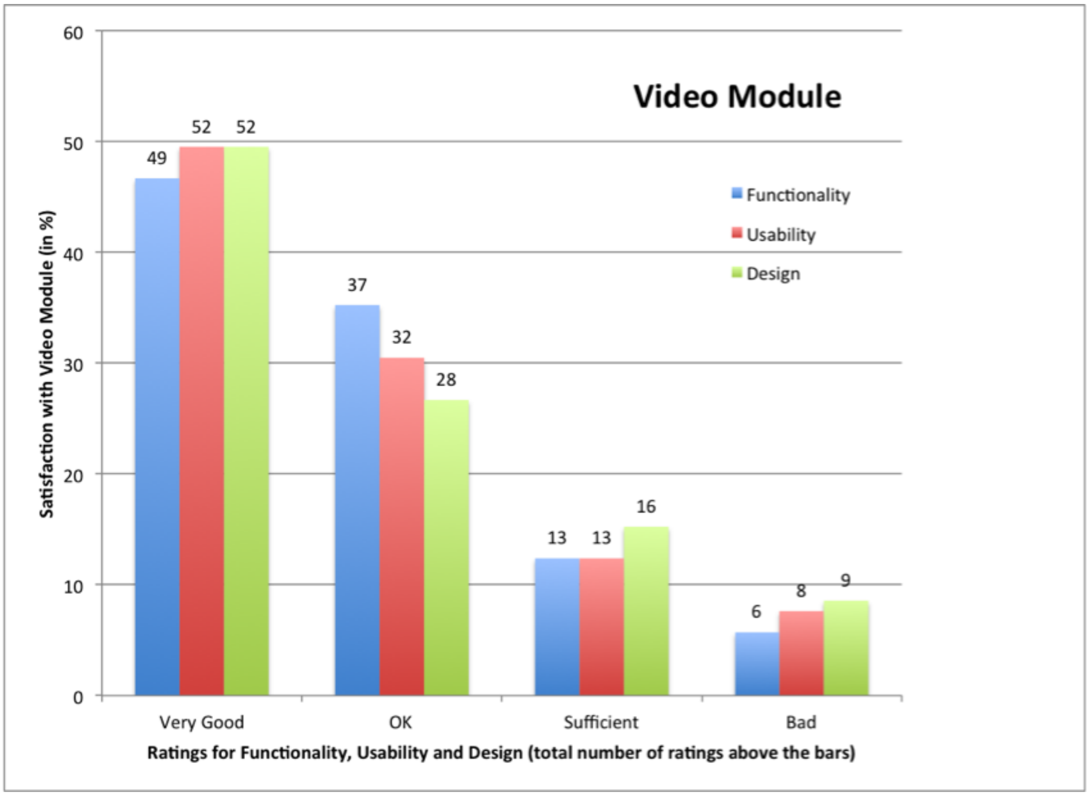

Figure 7: Rating Video-Module / Percent (Number of Votes)

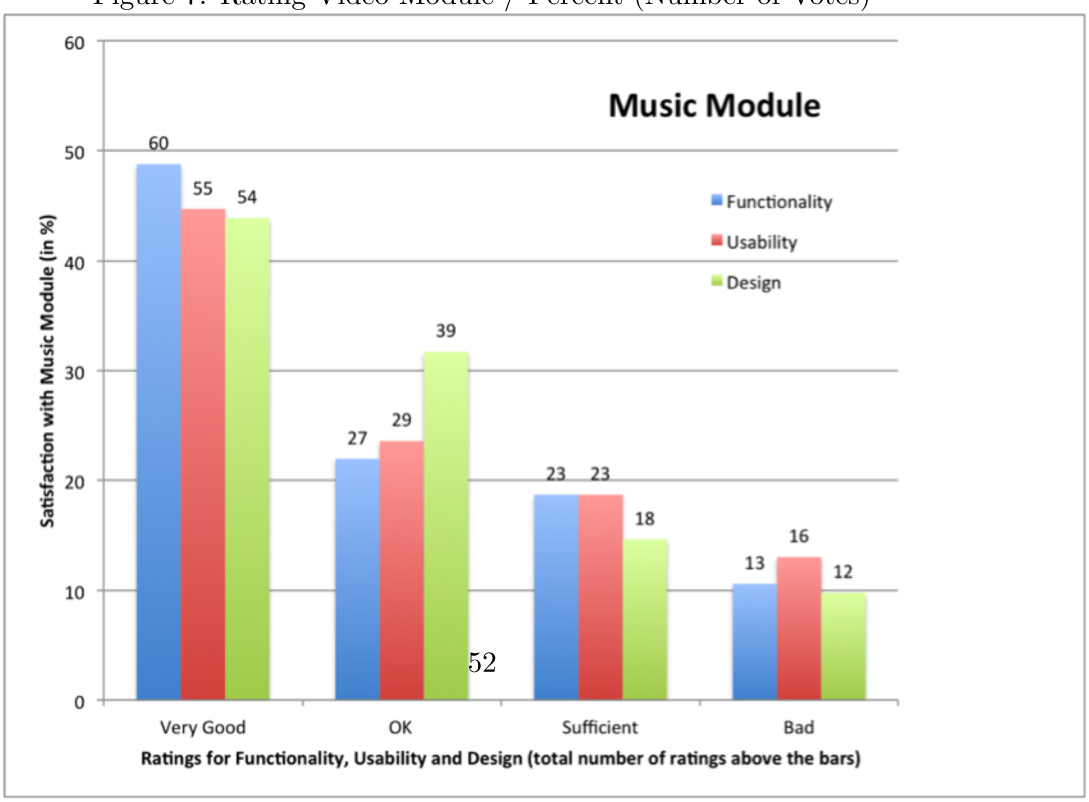

Figure 8: Rating Music-Module / Percent (Number of Votes)

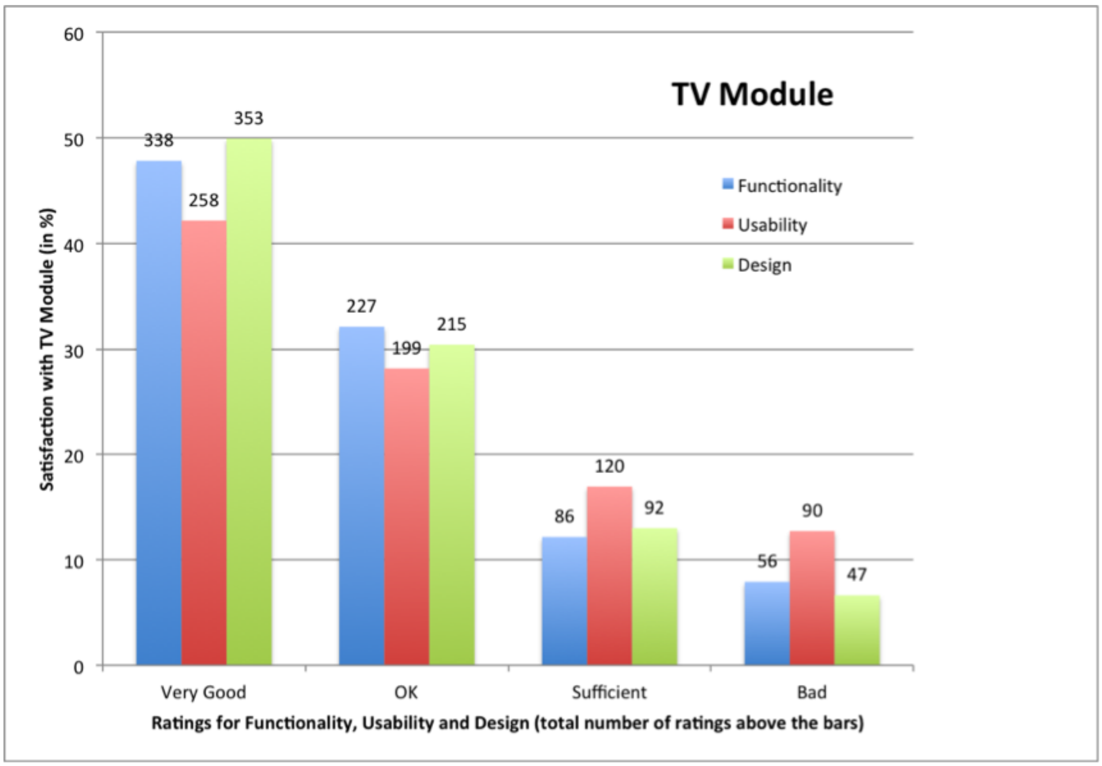

Figure 9: Rating TV-Module / Percent (Number of Votes)

Users reflected positively on the process of a community driven development. The possibility of influencing decisions stimulated the participation, at least early on. However, the idea of strong user involvement becomes potentially problematic at the point where users make enthusiastic and detailed suggestions, motivated by their specific (and sometimes individual) interests, only to find their ideas not taken up for various reasons. Even so, and in general, we found that users accepted circumstances where broader audience interests were prioritized. As described in the following quotation, users understand the process as a balance between their own interests and interests from others.

> User: “From my point of view I had have influence. I had the feeling that some of my suggestions that I mad were heart and accepted. Some details were not possible but then it worked. There were other things not accepted by many other people, where I say to myself ‘ok, I move back’. Otherwise it would be stupid to push things through alone when others not want to have it.”

The situation for members of the steering committee was more difficult. They had to balance their engagement among interests from users, interests from employees and their own interests. In contact with Omega employees they were expected to act as representatives from the community, in contact with the users they were expected to argue for the decisions made in the steering committee. Working with such different interests, and representing them, did not always lead to smooth results, as described in the following two quotations from two users in the steering committee:

> User Steering Committee “Many things were discussed in the steering committee, that we have collected all together. This is, I think, ok. There were some things in the background that were pushed [from Omega], but I think this is normal and generally speaking it worked fine.”

User Steering Committee (left the SC after the first alpha version was released): ”No, actually I think, v4 [the new software is referenced as version 4 of the media centre] will be a relatively big success, because there has been a lot done, but it is, as I have already said to [“Omega Manager”], it is not bad, but it is not the right thing for me.”

One of the users mentioned that the process of community driven development is applicable in cases where an active community with technically experienced users is already available. Aspects regarding technical expertise, the feeling of having a bearing on something, the domain of a hobby and the personal interest are the most important aspects for such an approach.

> User: "It is, I would say, a success. But I would not apply it to every kind of software. Rather I would apply it in the ways Omega did right now ... Omega really has a quite active community with many technically experienced members [...] I do it because it is a hobby, of course. ... as long as I have the feeling of having a certain kind of influence, and the result meets my personal needs, I will definitely stay and will go on participating."

4.4.7 Satisfaction of the employees

In comparison to the users, employees reflected more critically about the whole process. Several aspects including deadlines, the moderation process and the overall effort were commented on as crucial. One member of Omega clearly stated that the process moved from a user-driven to a business-driven one, as time went by and the top management of Omega pushed to sell a first version as early as possible:

> Omega Support: "In the end it was pushed from our side of course. And of course, because of time. Since, we were telling ourselves, we had to release a version someday. We had to sell something, because otherwise it was not possible to develop something further if there is nothing to sell. Therefore, it was economically driven."

But not all team members viewed the project that critically. The process provided Omega with a lot of suggestions and ideas. Even though the process was not managed optimally in the current project, nearly all members of Omega stated that new projects would run much better when considering the lessons learnt. They found the following issues critical: a clear task assignment, a commitment from the whole team, and a continuous communication process.

> Omega Manager: "The way we have done it is not optimal, definitely. Therefore, one learns of course, and can make it a bit better the next time. ... Today I believe that User Driven Development works when – and that many boundary conditions

> appear. So if certain things are clearly defined, the tasks are clearly distributed, the team supports it, and the communication with the users is set up, then it works."

One member of Omega also drew attention to the aspect that CDD probably would not work for every kind of software. The process is applicable for niche products (as Omega), but not for mass-market software. He mentioned the example of the tax software that had also been developed by Omega. Tax software is a standard package to manage the tax return and calculate every item correctly. For such a software the community driven development process is less applicable, because every function has to operate in a standardized way. Additionally, the same employee mentioned that CDD is probably more applicable for the development of incremental versions than for completely new ones.

> Omega Marketing: "So in general I think, User Driven Development fits as a method only when I develop existing software further, making variations, making new versions. Maybe it does not fit so well for a complete new development. ... Certainly it can work with niche products ... But especially with the small products, I think, it is an excellent method to motivate the commitment of the users."

4.4.8 Suggestions

Within the semi-structured interviews, several suggestions concerning improvements to the CDD process were made by users as well as by employees. This chapter summarizes the most important ones. The information and feedback process from the SC to the community (UP), it was felt, could be improved in several points. Because members of the steering committee discussed the requests of the whole community in weekly telephone calls, it was difficult for the users to follow and understand the reasons behind a decision. Therefore, some of the users asked for the weekly telephone calls of the SC to be done in public, e.g. in an online Teleconference. Alternatively, the discussion could have been recorded and made available later on for on-demand usage and reflection. Another improvement is related to the communication process about ongoing work. An employee of Omega suggested that certain decisions should be posted in a developer blog. This way discussion and information about decisions could be managed better:

> Omega Manager: "What I always missed, what would be nice, is a blog, a developer's blog, where one could inform the users. A

> blog is not a discussion platform, but something where I can read and post a comment, but discussion could take place somewhere else. ... So this mixture of discussion and information in the forum was not always successful."

One improvement referred to by most of the interviewed participants was the need for a better interconnection between forum and wiki. The requirement specification in the wiki needed, it was argued, to be linked to the related threads in the forum and vice versa. Alternatively it was suggested that an integrated wiki system with an entry for each topic with a related discussion thread might be constructed with a 'structure' realized with a graphical tree. Another functionality that also was requested was feedback and screenshot options directly within the software. One of the main drawbacks of current solutions is the de-contextualized discussion format. An integrated reference mode would provide the user and developer with a shared reference to the specific context.

> Omega Marketing: "what definitely would be helpful is a kind of ... feature request tool within the software. That means ... an opportunity to use shortcuts ... exactly at this point a screenshot could be captured and then attached to an e-mail ... so that users do not have the problem anymore of having to explain what they actually mean ... Because they always focus on a detail ... and we do not always fully understand what they mean, ... no one understands them the right way."

Beside the improvements related to a better design infrastructure, organizational aspects were also mentioned. A clear task separation among members within the steering committee would be valuable. Especially an assignment of responsibilities to defined software modules was requested. Because users draw attention to quite different functionalities, workshops or group discussions should focus on defined aspects within which the participating users really have practical domain knowledge.

> User: "one has no images at all, another one does not watch television and the third does not listen to music [using the system]. About what can I talk to them? Or they vote for something in which they do not really have an interest. It is better to have a module oriented manner that is oriented on functionalities ... where users participate who would use such a function, with them I would talk, and not only because they are interested [in talking], they need to have a desire or a reason for it."

4.5 Discussion

The case presented in this paper focuses on strong user involvement in the decision-making and design process for a commercial software package. The case exemplifies the difficulty of implementing the software in circumstances where a form of PD - a PD that reflects the new social and organisational conditions we discussed above, and our evaluation of the process - is intended to draw out some lessons for future work of this kind. We can frame the lesson with a very general first comment: good intentions are never enough. There is no doubt that Omega took the business of user participation very seriously and made every attempt to realise user needs where possible. Attempts were made to structure the process around what were perceived to be dual requirements. The first was that the user population needed to be 'representative' in some way although, as we have seen, there was no clear picture of what the relevant criteria should be. The second was that user involvement should be manageable, meaning that limits had to be placed on the number of participants, so that some structure of responsibility was envisaged and some communication methods had to be specified. Equally, there is no doubt that relative success and failure was dependant on a series of problems that were not always anticipated. Here, we summarise what those problems were, based on an open coding of the various responses we received using the 'grounded' mixed methods approach outlined above.

4.5.1 Motivations, Expectations and Risk

It was apparent that the motivations of the various participants varied widely, as did perceptions of risk. Where company representatives and developers were highly conscious of market factors, including the rapidly changing landscape and the need to expedite decision-making. As argued above, employees and management, as well as external contractors were (not all equally) aware of potential risks in terms of market competitiveness and time to market. Users were not. For them, motivations had more to do with just being 'interested' in the process, often at the level of the hobby. As the project evolved, it became clear that motivational factors were more complex than initially thought. Certainly, some individuals were willing to forego the commitment to a participatory process where they saw a gain in speed and efficiency. This motivational incongruence turned out to be very consequential in relation to the kinds of discussion users had in the online forum, and in their willingness (or otherwise) to deal with more technical forms, such as requirements summaries on the Wiki. Where company representatives wished to see a degree of structure in the online contributions and were frustrated by repetition, redundancy and lack of understanding of the design process, users expressed similar frustrations around the opaqueness of the decision- making process and the time taken to implement.

Expectations were problematized by the time required for developing a stable alpha version combined with an unclear communication strategy (see below). The company provided a screen-based preview version at the beginning and (active) users started to discuss functionalities and requirements in a very engaged manner (see also figure 4). After the first month, the level of contribution slowed down extremely because users were waiting for feedback referring to their input. On the company's side, the development of the alpha version took longer than expected while the state of development was not communicated. This constellation led to quite a bit of frustration within the user community. The most active participants were the least impressed after the release of the first alpha-version, since several aspects of the software had not been realized in the way they had anticipated. These users reacted more negatively to the alpha version than those who newly joined the project. Even those functions of the software, which were implemented as specified in the publicly available wiki, were perceived with concerns. Users complained that some of their own suggestions were not appropriately considered. On the other hand the uninvolved users, who tried out the version for the first time, gave positive comments in the public forum. The overall positive image was underlined by the good results of the feedback plugin. Nevertheless, there was a gap between previously involved and new users. It is rather surprising that previously uninvolved users reacted more positively than those who had been involved and this possibly reflects experience of the process as much as of the resultant system. Since not all wishes had been considered and since it had not been clear that they were discussed in the steering committee at all, some of the more involved users expressed their disappointment through this vehicle.

4.5.2 Lifecycle

It is well- known that a problem for user involvement in design projects with highly technical elements is that they tend to lose interest at certain points in the process, either because they see other (more managerial or technical) interests dominating proceedings or because they lack the willingness or capacity to understand what drives the process. Our observations, then, are not original in this respect excepting that what is found in smaller scale and organisationally specific projects is also found in the context we describe, a context where users have no organisational affiliations and are not bound by managerial authority. There is no doubt that a degree of participation decrease set in on the part, firstly, of the user population but also on the part of company representatives. Moreover, the form that this decrease takes varies. The reasons are manifold and are related to differences in expectation, and the distribution of competencies. Some users were passive almost from the outset. Out of 70 users who applied for the project and were allowed to participate, only 49 contributed at least one posting in the forum. Only a small subset of 15 users regularly took part over the entire time period. So the number of users decreases drastically when the postulated intention to participate requires active involvement over a longer period of time.

In the long run, even the moderators, well known for their high involvement in the online forum, showed a declining interest. The demands for structure meant that what had begun as a hobby- like interest became more professionalised, and more like work. For different reasons (e.g. illness, priority on the primary work) these users could invest only limited amounts of time and effort. They found it difficult to scan all new entries and conduct weekly telephone conferences. The effort and times as well as the responsibility of representing others are crucial aspects here. A shift from leisure activities in the sense of a hobby (as e.g. described from Jepessen and Molin, (2003) [151]) to activities that required effort then, goes some way towards explaining this 'participation decrease'.

The company was not immune to this phenomenon. What at first sight seemed to be an obvious cooperation – user and representatives from Omega discussing and deciding side by side – did not work out as had been originally intended. The users continuously asked for more information about the current development process. Members of Omega tried to inform users about the current state, but even for them it was not always clear how much time and effort would be needed to realize a certain kind of functionality. Additionally, the developer from the external company was kept out of the discussions, even though he was a member of the steering committee. He focused his work on the implementation instead of discussions in the forum. For the external development the wiki was the most important reference with the goal to transfer these requirements into a software system. In more general, employees focused on their core competencies, e.g. develop, marketing, other projects instead of continuously interacting with users in the forum. There was, in other words, a considerable variation in overall commitment.

4.5.3 Communication structures

As stated, communication structures like the online forum for the UP, a similar forum for the SC, and the Wiki were put in place to facilitate the communication process. What became progressively more clear, however, was that merely putting technologies in place proved insufficient. There is a case for arguing that the communication process on the online forum was in one sense overly democratic. On the face of it, and regardless of decisions subsequently made, there was a formal assumption that all contributions were to be viewed as having equal validity. Oddly, there was - given the existence of 'moderators' - relatively little moderation of online discussions. Equally, there was a lack of clarity about what each online facility was for and as a result people did not always treat them as default channels. There were, as we have seen, many occasions where telephone calls replaced an online forum and the Wiki was seriously underused as an information resource.

As highlighted by Farschian et al. (1999) [54] prototypes are an important and main reference point for distributed PD projects. Such artefacts can act as boundary objects (Star and Griesemer, 1989 [182], Stevens et al., 2010 [185]) that build a common ground and a shared understanding of the domain of interest. Our results also underline the high impact of such boundary objects – every time a new official version was released, e.g. in the form of a technical preview, alpha- and beta- versions, the involvement of the participants was at the highest level.

4.6 Conclusion: towards a community driven process

Our purpose here is not to be critical of PD processes, but to try to understand why such processes do or do not work well in conditions rather different from those to be found in more 'traditional' PD environments. We have identified three basic areas in which strains in the process were to be observed (although they evidently overlap). In conclusion, we might say something about how these pitfalls could feasibly be avoided. We argue below that there are two, inter-related, 'management' issues that need to be attended to in the circumstances we describe. To remind ourselves, these new participative processes are increasingly mediated by tools, address larger and more heterogeneous populations, and implicate complex 'producer' and 'consumer' relationships.

The management of heterogeneity As argued above, there were significant differences to be found in motivation, expectation and perception of risk on the part of various participants: This, despite an overall commitment to the principles of participatory work by (most of) the participants. Very broadly, this reflected a difference between professional and amateur commitment. The process was initiated by a commercial company which had some experience in participation in the sense that it encouraged feedback from users. This, however, was new insofar as there was the clear implication that design would be predicated on user input. Arguably, the company did not fully appreciate how problematic that would prove to be when managing a heterogeneous group of users, distributed in a variety of ways including skill and availability. Further, one can argue that there was a lack of clarity over exactly what the roles of the various members of these groups were intended to be, at least from the point of view of the user population, who sometimes failed to see how design decisions related to their inputs. In addition, over time, the orientation of company members towards the commercialisation of the product became more and more apparent, whilst a disinclination to do 'work' became equally apparent on the part of users. To some extent this may be inevitable in lengthy participatory processes. After all, users often have other and more important demands on their time. There is no reason, however, why these differences in expectation and effort cannot be made explicit. It ought, at least in outline, to be possible to schedule effort so that participants are aware of what might be required of them, and when. In our view, one of the failures of the project we discuss is that the company took the goodwill of participants for granted, perhaps because they were already familiar with some of them as a result of prior participation, perhaps because they did not fully anticipate other demands which arose, and hence did not prepare them for the efforts that were ultimately required of them. It was quite clear from our data that users and moderators became appreciably less motivated in the absence of prompt and clear indications of what decisions had been made and why.

It is also the case, in this instance, that commitment to the participatory principle was less than total on the part of third party elements, and hardly any attempts were made to manage their involvement. Instead of participating in discussions on a regular basis, the external development focused on the implementation as specified in the requirement document. Our results show, that more preparation is necessary here also on the company side, e.g. regular information about the state of implementation. Current states and issues should be made more explicit in order to create transparency and act on the same knowledge base, e.g. what is realized already, what are the next steps and priorities.

The management of tools It was always the intention that a significant part of the participatory effort (though not all of it) would take place online. Social media tools such as the Wiki were employed for this task. A second failure, however, was in not realising how such tools might be used in practice, and by whom. The tools proved inadequate in a variety of ways. They provided no means for moderators to sum up and represent a variety of viewpoints easily, in part because there was little or no structuring of the 'threads' on the Wiki. Separation of function between the tools was also less than perfect, and there was little integration of the different media (the forum and the wiki). Our results indicate that discussion and decision space need to be better connected with each other. The contributions from the users (forum entries in UP) and the resulting decisions (wiki entries from SC) were not really related with each other. This is a crucial point of PD 'in the wild', and can be supported by more transparency within the discussion space (e.g. publish latest decisions also here), or with more cascaded forms towards final results (e.g. offer additional polls before final decision or summarize requirements in an easy to interpret feature list).

An improvement of the communication chain between end user community and SC, and giving more design power to users, could also help to stimulate participation. While problems, improvements and new ideas related to the software became particularly visible at use-time, it is valuable to offer users integrated feedback channels that can be triggered during use, e.g. by offering in-situ feedback tools that enable users to make screenshots and annotate them in a flexible manner (Hess et al., 2011 [87], Hess et al., 2012 [93]). Such feedback channels can be integrated into early mock-ups and can be directly linked to the discussion space. Visualization is an important aspect of this. The user community is not trained to deal with technical specifications, and made relatively little attempt to monitor them. In part, this is simply because they found it difficult to understand. Visualization tools could make an appreciable difference here, and could work in a way that is analogous to the paper 'mock ups' to be found in more traditional approaches. Such technologies would support a more structured, context-focussed and module-oriented form of discussion. Feedback gathered this way can be used to obtain an overview of the overall satisfaction with modules (as done in our study with the feedback plugin that enabled polls) and also can be used to collect qualitative data that can act as marker to be discussed in the community or been used by the development directly. One further point that might be made is that there is a difference between tools which support information provision and tools which support participation. The forum clearly supported the latter but no tool was identified which served the purpose of keeping participants 'up to speed', hence the demand for a 'developer's blog'.

In sum, a combination of socio-technical factors affect outcomes in this project, just as in every project. In itself, that is no great insight. Hopefully, however, we have identified very specific factors which need to be addressed when attempts are made to manage participatory processes which entail distributed and heterogeneous members. As a framing device, we can think about these issues as 'infrastructuring' issues (Pipek and Wulf, 2009 [140]). The development of any socio-technical infrastructure can be thought of as both a political and a practical matter. Our discussion of the management of heterogeneity forms part of a more general issue, that of the 'politics of participation'. While we have no doubts about the benefits that participation brings to design, those benefits are inevitably mediated. Factors such as the degree to which a common understanding of purpose is present, who is involved, for what purpose and when are critical. In much the same way, the management of practice in this context is very much (though not exclusively) the management of tool use. Social media technologies support participation in principle, but the success or otherwise of their deployment depends on a range of quite specific factors, as we have shown. Within the "infrastructuring" framework, the "point of infrastructure" is the point where the tensions between possible use options and necessary use options become so strong that use practice is interrupted ("infrastructure breakdown") and the user switches to "design mode" insofar as she starts to reconceptualise her infrastructure in order to satisfy her needs. We have tried to show that these critical points are not necessarily aligned in participatory work of the kind we describe - 'users' and company representatives do not always see this 'point of infrastrusture' in the same way and the absence of tools which mediate these views successfully, outcomes are not necessarily optimal.

New forms of infrastructure are necessary to link design and use, in the sense of a 'design for design after design' (Ehn, 2008) [51], so that each stakeholder can be integrated and supported regarding his/her competences and interests, e.g. by offering options to customize the product, by offering integrated feedback channels, by linking this feedback to an public space also open for controversies, by offering discussion and voting options and by providing continuous feedback from the companies side in, for instance, a developer blog. Ultimately, our point is that for communities of a distributed kind to engage in successful participatory processes they need to become communities with shared perspectives and shared practices. This is an entirely non-trivial matter.

5 Understanding and supporting cross-platform usage in the living room[2]

Abstract

Nowadays users can choose TV and video content from diverse broadcast and online sources. The Internets many functionalities, such as communication, sharing and other information services, enrich the TV experience. The convergence of media is not only visible in the broader functions of one device, e.g. broadcast and online access through a Media Center system, but is also reflected in the interconnectedness of different devices. In order to understand the design dimensions for further Social TV applications, we conducted different empirical studies, including a diary study, interviews and creative workshops. The results indicate that several forms of parallel and convergent media use have already been established. We identified flexible switching of devices and services related to television and video content. While the empirical results also confirmed limitations of isolated applications and services, we will present a technological infrastructure that supports Social TV in a more integrated and flexible manner. Furthermore, we will describe two use-cases that show the potential of interconnected design concepts.

5.1 Introduction

Television is one of the mainstream media sources in the living room. It is used as a source of information and as an established medium for relaxation or entertainment, consumed alone or with friends or other household members. Traditionally scheduled via broadcast, new technologies and devices enable a fast and easy access to additional rich-media content and Video on Demand services have become more and more important within the last few years [142]. By accessing audiovisual content through the Internet or recording television shows with personal video recorders (PVR), users are free to choose when they want to watch. While new technologies allow for a more flexible and personalized form of media consumption, it could be argued that the social character of television has decreased. However, despite having the option to choose TV content individually, users are still guided by the watching behavior of others, e.g. by watching recorded content the same day it was broadcasted on television or sharing contents with friends

[2]This chapter has been published as an journal paper in Entertainment Computing, 2012: Hess, J., Ley, B., Ogonowski, C., Wan, L. and Wulf, V. (2012): Understanding and supporting cross-platform usage in the living room, In Entertainment Computing, Volume 3, Issue 2, May 2012, Pages 37-47.

and then talking about it [10]. The exploration and the support of social intercommunication in television environments is an emerging field of research in academia and industry [36].

Several solutions such as Google TV, Boxee and Miso, combine TV and the web, by offering integrated social services. Various techniques and functionalities enable the user to share content and to communicate with others over a distance. As one of the key aspects, research around Social TV explores the social character of television concerning specific details. Related work has started to focus on exploring the design area of television, e.g. by integrating an online channel for communication via text chat [3]. Others have explored the pros and cons of text and audio chat [98], the influence of the program genre [67] and the use of additional personal devices [34]. As television and media contents can be delivered to several platforms, such as the PC, mobile devices and the TV set, the design area is huge. Therefore, current work has a strong focus on bridging aspects between several devices [34, 120, 134].

In reference to such device-bridging approaches that are characterized by more integrated services, many questions regarding valuable and useful concepts in an interconnected Social TV environment remain unanswered. From an empirical point of view, it is important to understand the current practice of multi-device media usage within domestic contexts. From a technological point of view, we need to identify the way in which newly integrated concepts should be designed, in order to offer additional value to the users.

In this work, we will describe our integrated research concept, in order to understand the practice of parallel and convergent media usage in domestic environments. For this reason, we set up a Living Lab, with 27 participants from 16 households, as a means of promoting participative user integration, as well as to conduct long-term evaluation studies. As a first step, we conducted a field study with the goal of exploring the every day media usage of our participants, which was done by having them keep a media diary. As a second step, we organized creative workshops where we discussed integrated social media concepts in groups. We present the results of that design sessions and new implications for design. In order to address the identified requirements for an integrated cross-device usage, a flexible SocialMedia architecture should overcome the limitations of standalone solutions. The presented framework enables universal access of video and TV content on different devices. Social services can also be integrated flexibly by connecting with a community server. In order to show the potential of our framework, we will also present two use-cases for cross-device usage (bookmarking recommendation). We will then highlight the value of universal access and seamless interaction that comes with more integrated scenarios.

5.2 Related work

In HCI research, the home environment has become a major point of interest. Home media, such as television, Internet, and (online) radio, have received considerable attention in each area. However, only few attempts have been made to treat interactive home services and devices as an integrated concept. O'Brien et al. have pointed out that "sharing at home is a cooperative activity. [...] Household technologies simply need to fit into this pattern of activity" [131]. This signals both the importance of integrated home technologies and the consideration of established social patterns of use.

5.2.1 TV-centric systems

Watching television has changed in several respects, as new technology has changed what was once a simple broadcast medium. Television is embedded in a process that Barkhuus Brown [10] describe as the video media lifecycle. They investigated the changing practice of watching television among early adopters of personal hard-disk video recorders and video on demand (VOD) services. They found that watching TV involves an active process of choosing content from the TV guide, playing back the chosen content from a stored collection, fast-forwarding and pausing during playback. The TV lifecycle also includes collecting an archive of shows, and sharing and discussing those with others. Studies from Bernhaupt et al. [17], Obrist et al. [132] and Tsekleves et al. [146] report on ethnographic insights related to the role of television and other types of media in daily life. Bernhaupt et al. [17] identified trends regarding personalization, privacy and communication. Watching TV was identified as a main activity that participants liked to share with others. Tsekleves et al. [146] also highlight the meaning of the TV set as a shared display for collaborative access to different kinds of content. Based on their pre-study, they developed a mobile application that provides the participant with the possibility to choose from different media on the personal device and to display them on the TV set. The possibility to share photos and videos this way was very much appreciated by the users.

The unified-EPG [134] is a good example of the combination of PC and TV, in order to handle the ever-increasing amount of media content. The result of the in-situ evaluation showed that the participants liked the idea of the Unified EPG, as it combines different media sources (TV, PC, radio, external hard disk, etc.) and offers an easy and unified access to content on the TV set. Participants were able to handle the huge amount of multimedia content this way. The PC was favored over other devices for organizing the content, as it is more comfortable than the TV. Another study showed that using the handheld device as a second screen in an interactive TV environment enriches the experience of watching TV [34]. In particular, the second display was used for previewing and viewing content and to access enriched information, which was the most valued usage. Huang et al. [98] empirically explored the activity of chatting while watching television. They found that the precise realization of a supporting tool for communication has a huge influence on the user acceptance. In their study, participants preferred text chat rather than voice chat because of its less interrupting character. Geerts et al. [67] report on how the program genre of a TV show influences the communication behavior of users. They found that discussion and recommendation are closely related to the genre, while e.g., news and soaps stimulate discussion while watching, and movies and documentations stimulate the discussion afterwards.

5.2.2 Cross media systems in general

Other works discuss the integration of various devices in a more general matter. Rodden et al. [143] focus on the interplay between interactive services/devices in households and built a jigsaw-like toolkit for the user to configure the services in the home by connecting components and thus composing various arrangements through the coupling of pieces. An IPTV platform developed by Obrist et al. [133] supported local communities. Rhub, a group-socializing tool developed by Heyer et al. [96] enables cross-channel communication by transferring text-messages to several applications on mobile networks and the web. Participants from their study used the tool mostly for ad-hoc coordination rather than chatting. Prata et al. [136] presented an approach to generate dynamic cross-media learning contexts from iTV and then made it accessible from several types of devices. Kane et al. [106] explored cross-device web usage on PCs and mobile devices – a more integrated approach that has the potential to improve the usability of the mobile web. Pipet [121] is a cross-device photo-sharing tool that enables a physical interaction style.

The goal of our research is to gather evidence about user requirements and preferences for an integrated social media system to be applied in future design and development. While the exploration of user requirements for such integrated systems is not trivial, we strongly valued empirical methods. In order to cooperate with potential users for an extended period of time, we set-up a Living Lab with 16 households. Within this work, we will present our results on current media usage within those households. We also conducted several mock-up and design sessions and will present a framework for a more flexible TV-centric cross media infrastructure and will describe more integrated use cases.

5.3 SocialMedia project

The term 'social media' has become very popular within the last few years. In the context of Web 2.0, Kaplan and Haenlein define social media as "a group of Internet-based applications that build on the ideological and technological foundations of Web 2.0, and that allow the creation and exchange of User Generated Content" [107]. Even if this definition is commonly accepted, social media should be considered from a broader understanding of content that includes user-generated as well as professional-generated content, which social options can reference, e.g. in form of comments, ratings or chats.

Based on this assumption, with the SocialMedia project we want to develop a cross-platform framework to foster and integrate communication between different domain-specific functionalities. Generating and sharing content in different media environments and between different devices should become more user-friendly with the help of technological support. The central issues in the research project SocialMedia are:

- From the user's point of view, which kinds of cross-platform usage, media convergence and communication options are useful?
- Which tools, concepts and usage scenarios can support the user's needs?
- How do new concepts affect the social behavior, e.g. in social networks?

To answer these research questions, two pre-requisites should be met: On the one hand, the development of a concept to integrate the usage of various existing media (integrated approach). On the other hand, user requirements should be acquired and evaluated in real situations and in a practice-oriented way.

5.4 Living Lab concept

In the design and evaluation process of new technological artifacts, the participation of users and the feedback process between users and developers has an increasingly important impact on building usable, acceptable and innovative applications and services. The novel concept of Living Labs makes use of these characteristics and can basically be understood as an environment that integrates users, technology and business in an open and innovative development process, which takes the real usage contexts into account [5, 127]. Følstad analyzed several Living Labs in the context of ICT-innovation and defined nine general characteristics of the heterogeneous implementation of such a concept [60]. The most relevant and the strongest characteristics are the support of co-creation research and development processes by involving users into innovation processes at an early stage, for "sensing, prototyping, validating and refining complex solutions in multiple and evolving real life contexts" [53]. The fact that users can actively make contributions to research and development activities, sets the Living Lab concept apart from others. Living Labs offer the possibility of capturing user experiences and gaining relevant information from everyday practices as well as routines, to create new ideas together with the stakeholders. The long-term cooperation between the stakeholders helps evaluating prototypes in real usage contexts over a long period of time. These general characteristics help increase the validity of research results and enhance the development process. In this regard, empirical methods have been applied to explore user behavior and media usage in order to identify significant requirements. The context of everyday practices and routines implies a paradigm change on how to think about the development and design cycle. Especially domains like the user's home, pastime activities and other highly rated privacy contexts are qualified for such a concept.

Living Labs have been applied in domestic as well as in professional contexts. A large review of literature and previous studies show that the concept is utilized heterogeneously and in different modes and on different levels. Especially labs dealing with the development of Home-IT, communication or entertainment technologies adopt the characteristics of real life contexts in two different ways [90]. On the one hand, Living Labs use an artificial environment, e.g. test centers, where a standardized living room is simulated. The PlaceLab of the MIT, for example, uses such a controlled environment structure [103]; it offers multi-observation possibilities, which supply predominantly quantitative data and also well comparable data. Empirical studies can be organized with a large number of participants, but they are limited by short-term evaluation. Living Labs on the other hand, use real life test beds with different types of households. Researchers from the project 'iiTV@Home: Field trial in Salzburg' chose such a concept to gain a deeper understanding of practice, context and social dimensions in households [132]. This non-artificial lab structure offers long-term evaluation in situ, which makes a deeper insight into specific environments possible. Both directions mentioned have pros and cons. Non-artificial labs are often limited to a small number of participants, because of a higher time and work exposure in the field.

To address the project goal, we chose a multidimensional Living Lab concept, which combines different structures to take advantage of various lab concepts. Our lab is named 'SocialMedia Experience and Design Lab (SMEDL)', because user experience and the design of new technological concepts in the field of home entertainment are strongly related with each other. The lab can be described as an infrastructure with real households supporting empirical studies and integrating potential users in the design process in the long run. A close cooperation with the user helps identifying user-driven innovations, e.g. for collecting new ideas. It also facilitates evaluation processes in order to gather feedback for early design mock-ups. Running prototypes can also be tested in practice in order to gain (in-situ) feedback directly.

SMEDL consists of different environments, which help collect qualitative and quantitative data. One of them is SMEDL.Stat, a stationary controlled test bed (see Figure 10) that reproduces a standard living room at our university and is used e.g. for short time evaluation within first user tests. With this structure we can measure user feedback on a very exact level in order to gain data in a controlled setting. A real world test bed (SMEDL.Local), including several households in an urban region of Siegen, Germany, characterizes the most important part of the lab [91] (see Figure 11). The setting is used for long-term evaluation studies and continuous user participation. Households are equipped with new technology (media center system, high-definition TV and smartphones), which are to be integrated into daily behaviors. Within the local lab we can explore the integration of new technological artifacts, the media usage and its changes over a longer period of time by gathering qualitative as well as quantitative data. In the long run, we also want to involve users from online communities. By doing this we can gather ideas and test concepts with a larger number of test persons.

In order to find participants for SMEDL.Local, we started a call for applications via local newspapers and radio. In a first round we selected

Figure 10: SMEDL.Stat – Stationary lab

Figure 11: SMEDL.Local – Watching TV in a household

8 households with 15 participants (6 male, 9 female). As a basis of the selection process, we conducted semi-structured telephone interviews with every household to find out more about the structure of the household, socio-demographical facts, education, income, media usage, technical skills regarding their experience in dealing with media center systems and smartphones, existing technical equipment and the motivation for their participation. In a second step, we asked our selected participants to recruit other interested households within their local social network, so that SMEDL.Local consisted of both participants that knew each other and those who did not. The reason for this was that we were interested to see how users intercommunicate about their media usage and how new integrated social media concepts support the establishment of new contacts. In the second application round, we selected 8 additional households (8 male, 4 female). The final structure of SMEDL.Local consisted of 27 participants (14 male, 13 female) divided into 4 single households without children, 2 single with children, 5 couples without children and 5 couples with children.

5.5 Methodology, approach results

In the first phase of our project we started our empirical work focusing on exploring and understanding the current media usage in domestic environments. The advantage of SMEDL.Local lies within a profound understanding of household structures and their media behavior to identify requirements for new integrated social media concepts. We chose several methods to reach that goal. In a first step, we conducted a diary study featuring a media diary, in order to explore the participants' daily media usage without technical or personnel interventions. Based on the results of the study, we created several concepts for a new integrated social media application for TV and smartphones. Afterwards, we discussed the concepts in two different workshops together with the participants of SMEDL.Local. Both studies took place before we equipped the households with media center systems, high definition TVs and smartphones.

5.5.1 Diary Study

Diary studies are a common approach in HCI to be able to explore the situation or circumstances in question through the participants themselves [32]. Another approach to help participants with self-reflection, is called Cultural Probes [65]. Several studies have used this approach for different reasons and in different contexts [17, 26]. In comparison to diary studies, Probes are well-designed artifacts that stimulate feedback in a more open and creative manner. While both approaches have their strengths – a more structured feedback through diaries [91] and more open feedback through Probes – we made value from both. We focused our design on the media diaries, but also included a camera and bundled everything in a nice box. With this documentation material, we enabled participants to reflect on their media usage on all available devices with a strong focus on social aspects. Below, we have described our approach and the results of a three-week field study within the local lab.

Approach To understand the daily media usage of our participants and to increase their understanding of our research activities, we designed diaries and passed them out to the household for a three-week period of self-documentation. The boxes contained one media diary for each participant in the household, a digital camera, a privacy policy, a stand-up display to remind participants of the documentation and some sweets for motivation (see Figure 12).

The diary represents the most important part in the box. It contains semi-structured pages on which the participants are told to document every single media usage with the following information:

- date and time of usage
- number of involved persons
- kind of media (TV, video, Internet, cinema, other) and parallel usage with other media
- content of media
- motivation for media usage
- intercommunication with others about the content

Furthermore, we included several special pages to better understand the participants' regional, national and international social networks, pastime activities and additional insights into how they live. With the camera participants were able to document certain aspects of their media usage to give us more visual insights. The diary study was also helpful in establishing a trustful relationship between participants and researchers. After the three-week self-documentation process, we collected the boxes and conducted additional interviews with each participant in the household to reflect on the current

Figure 12: SocialMedia documentation box

media usage as well as on the relevance of specific media (TV, PC/Internet, mobile phone) and the diary study itself. Overall, we received 26 duly completed diaries (14 male, 12 female) from the 27 participants of SMEDL.Local with a number of 669 entries in total. One female participant was absent during this part of the study and could not take part.

Results: convergent media usage In the following chapter, we will summarize the most important findings of the diary study and the additional interviews. Many entries within the diaries relate to daily routines and group activities. We also identified a trend that watching television is supplemented by other activities, in particular, by the use of other media. We found that the participants in our test bed used television and Internet based applications (e.g. web browsing, e-mail, instant messaging, social communities and video on demand services) simultaneously on different devices. One of our participants compared this with a ritual: "The one hand turns on the television while the other hand turns on my laptop. [...] Starting Outlook [e-mail client], checking e-mails and then flipping through TV channels to see if anything is interesting for me." (m27, higher technical expertise, single without children). We found that TV and Internet are interwoven in their usage, especially to (1) search for information, (2) to stay in contact with friends or colleagues and (3) the selection of devices for media consumption.

Information search

A main aspect for the simultaneous usage of the Internet is to search for information. Two of the participants provided us with examples where their TV consumption made them want to search for information on the Internet during or after watching a television show (m36, higher technical expertise, couple with children) (m42, lower technical expertise, single household without children). The laptop, as a secondary device, was normally used for that activity. In one household, where an Internet-capable media center system was already available, participants regularly switched between TV and Internet on the television screen, especially during the commercial breaks. As a reason, the request for additional information was mentioned (m30, higher technical expertise, couple without children). In contrast to him, his fiancée also used the Internet for information access but preferred to use the laptop. She said that the media center system was too inconvenient for her, because of the multiple input devices. In this context, she noted that a single, universal remote control would be helpful (f35, minor technical expertise, couple without children). In another case the smartphone was used to check e-mails, the weather forecast (non-TV related) and information related to the video content (m36, higher technical expertise, couple without children). Another participant, who also used the smartphone simultaneously with his TV consumption, was not satisfied with the size of the smartphone's screen and wanted to have an iPad for such needs (m33, higher technical expertise, single household without children). He would also be interested in an integrated solution on the TV screen, which does not destroy the character of the entertainment. Even participants with no technical experience in media center systems and smartphones asked for more integrated concepts "to get value out of 'idle time' [...] so that I do not have to stand up and turn on the computer when I'm interested in something" (f45, minor technical expertise, single household without children).

Social interactions

Participants used different communication services to stay in contact with friends. Intercommunication about television and video content happens via telephone, face-to-face and via instant messaging. One participant used to talk about TV series with his cousin on the phone, and sometimes they met to watch TV series together (m37, higher technical expertise, couple without children). The exchange via social networks is too impersonal for some of the participants because the buddy list includes friends and also other people. That is why they would not post every activity for everyone of them to see and likewise they are not interested in reading posts from others (m35, minor technical expertise, single household without children). The interest in synchronous communication varies from person to person.

One of the participants gave us an example where a friend called him on the phone during a motorsport show. For him it was more of a disruption "Damn it! Now I can't watch and relax any more" (m42, minor technical expertise, couple with children). In contrast to this, a younger participant described completely different behavior. She often talked asynchronously about TV content with friends on the phone and face-to-face at school the next day. During commercial breaks, she used to chat with friends about the TV content if her chat partner watched the same show, otherwise they conversed about other topics (f17, minor technical expertise, daughter of couple with children). The integration of a video camera into the television set for video chats is also mentioned as an interesting feature, however, not when watching TV or other video content (m37, higher technical expertise, couple with children).

Source of content

TV is only one of the used entertainment and information sources. Video content is also often watched on laptop or PC, because of a larger variety of content available and the flexible consumption time. In general, we identified a trend towards an integrated usage behavior, which is well described in the following statement: "In the past it [television] was very important, because it was one of the main media sources, and I created my media consumption according to the TV schedule. [...] now my media consumption is more based on on-demand and I do not have to deal with the restrictions of TV schedule anymore." (m35, minor technical expertise, single household without children). Watching content in a non-linear way is also an important factor for others. One participant, for example, watches on-demand content saved to a hard disc or DVD, thus detaching it from the given TV schedule (m33, higher technical expertise, single household without children). The on-demand character also enables ad-hoc access to a wide range of music: "with friends [I] was listening to music on YouTube at a party. Because there was no other music equipment, we played the music for the party via a laptop [...] It was quite funny because of [...] the different tastes [of the attending persons]. Then, on the next day, I bought an album from a band that I had not known before" (m35, minor technical expertise, single household without children).

The Internet is an important source for audio and video content. One of the participants regularly watches videos on a laptop, because English-language content is very important to her, but barely available on German television (f37, minor technical expertise, single with children). However, watching videos on a laptop/PC is not always the best choice. One participant summed up his preference for the output device in relation to the content: “if the aesthetic of a movie is important to me, then I do not want to watch it on the screen [of the laptop/PC] but on TV. When focusing on consumption in general, the computer is sufficient. The advantage of the PC is its multi-functionality for doing things [other on- and off-line activities] simultaneously, e.g. listening to music or watching series” (m35, minor technical expertise, single household without children). Within the diaries we identified several entries that refer to the simultaneous usage of different video sources (e.g. on TV and PC). Even if several types of media are running simultaneously, only one has the focus of the user. A typical example here is the media behavior of a boy who played online games, chatted with buddies per voice chat and watched cartoons on TV, all simultaneously (m14, minor technical expertise, son of single with children).

The diary study provided insights into how participants use media on different devices and in different contexts. It became clear that TV and Internet are strongly interwoven, even for households without media-center systems. Laptop and smartphones are used simultaneously or later, in reference to TV content or to obtain information or consume media on demand. For different reasons, the participants ‘jump’ between different sources of content. Such jumps take place on one device, e.g. switching between broadcast and online mode on the media center system, and between different devices as well. The reason for a jump can also be the need for social exchange, e.g. to talk about a TV show. The media content was mentioned to be a relevant topic in phone calls and chats with friends. Results of that pre-study clearly indicated that further solutions need to bridge the gap between all available devices, rather than providing an all-in-one solution. Every device has different strengths, e.g. the size of the display, the flexibility of use, input capabilities, personal or public use etc., therefore integrated solutions need to make value of all these options. As a result, several integrated social media concepts were realized with paper mock-ups and PowerPoint slides. As a next step, we discussed the approaches together with the households.

5.5.2 Creative workshops

After the diary study, we conducted two workshops with the participants of SMEDL.Local. We focused on first ideas and thoughts related to new social media concepts that bridge the gap between television, PCs and smartphones. Within the workshops, we first discussed concepts that were developed from the diary entries and interviews. The concepts were put into groups regarding different functionalities along the following dimensions:

- Social Networks: intercommunication on audiovisual content e.g. via IM, Twitter, Facebook etc., awareness about the status of friends, community building (see Figure 13)
- Additional information: integrated channels for collecting additional information about the content watched (see Figure 14)
- Recommendation: give and receive information about interesting content
- Personalization: define device specific content, receive additional information and personal messages, customize remote control

The discussion was semi-structured along those topics. Both workshops where recorded on video and audio for a subsequent analysis.

Approach The first workshop addressed participants with higher technical skills. We invited 8 attendees (5 male, 3 female) from 6 households. The workshop consisted of two parts. We started with a brainstorming session along the previously mentioned dimensions, where the participants had the opportunity to describe how they used existing social media concepts, what usage problems they had and how new concepts should be designed in the future. We split the group into two moderated subgroups and provided paper and pens for the participants to visualize their ideas and thoughts (see Figure 15). In the second part of the first workshop, we discussed concepts we had developed subsequent to the diary study, which we presented as paper mock-ups and PowerPoint slides (see Figure 16). We asked the participants to explain the assumed functionalities of the presented concepts and we then discussed them critically. We retained the same group constellation as in the first part of the workshop.

The second workshop addressed participants with middle and lower technical skills (i.e. little or non-existing experience with media center systems or smartphones). 10 participants (5 male, 5 female) from six households took part. Because of the participants' lack of experience, we omitted the brainstorming part and instead gave a short hands-on demonstration of current smartphone and media center technologies. Afterwards, we split the participants into 3 groups and then put the mock-ups and PowerPoint slides of our concepts up for discussion.

Results: concept reflections In this chapter, we will describe interesting results from the creative workshops. We have classified the results into

Figure 13: Integrated Twitter-concept for TV interface (mock-up)

Figure 14: Smartphone application for additional content information retrieval (mock-up)

Figure 15: Creative workshop Part 1

Figure 16: Creative workshop Part 2

two major categories: integrated information communication and integrated concepts devices regarding a device-independent content access.

Integrated Concepts Devices

During the workshops, we identified several cross-platform issues we had to deal with. The following statement from one of the participants characterizes that circumstance quite well: "too many [different] standards and offers [of content providers][. . .] I'm confused about that [. . .] I would prefer if there was an understandable concept with access to any digital content [source]" (e.g. YouTube, Netflix, VoD products of TV broadcasting stations). As a solution the participant asked for "a platform that is the same on all devices [. . .] like a kind of standard [. . .] so that there is a feeling, like being at home" (m36, higher technical expertise, couple with children).

Within the workshops we identified strong demands for an integration of different devices that are available at home (e.g. TV, laptop, PC, tablet PC and smartphone). Some of the participants would like to have additional information about the TV content or communication tools on their smartphones or tablet PCs. Another participant, already familiar with retrieving related content information with a smartphone, asked for a more integrated solution that can also show this information on the TV screen (m36, higher technical expertise, couple without children). Another participant would like to have the information on a television and a mobile device simultaneously (f37, minor technical expertise, single with children). During the discussion, a broad consent was found that such a decision should be able to be made flexibly and individually. The same issue occurred while discussing communication concepts as it is relevant to decide for yourself if personal messages are to be displayed on the TV screen while watching TV with others (m36, higher technical expertise, couple without children). One of the groups started sketching a model and ended up with a solution where event notifications played an important role. While notifications about incoming messages should be received on the mobile device, the decision about where the content should be displayed (television or mobile) should be flexibly configured (see Figure 17).

Another important aspect is the role of the mobile device as a remote control. Independent of the level of their technical expertise, the participants would like to be able to use their smartphone as a remote control device for the TV. However, some of the participants were uncertain about this concept because of the small keys and the missing haptic feedback they would prefer a physical keyboard instead. Another reason against using the smartphone as a remote control for the TV, is that mobile phones are usually personal devices that are not shared with others. However, the TV,

Figure 17: Integrated notification process (based on the sketch from the workshop)

especially in the living room, is used by every family member and this also applies to the remote control (f41, minor technical expertise, single with children) (m49, minor technical expertise, couple with children). Despite those concerns the smartphone offers a good options for more flexibility and a better customizability and can be used as a control device (e.g. to trigger on the recording functionality of the media center system) as well as an output device (e.g. to watch video content on the way home) (m36, higher technical expertise, couple with children).

Integrated information communication

Two participants who knew each other mentioned that media content is always a huge topic when talking to each other. They use the phone to talk about new movies and TV-series: "Mostly we talk about such things on the phone [. . .] actually we always talk about a media topic. For example, a movie that one of us has recently seen" (m37, higher technical expertise, couple without children). In this context the workshop's participants brought up some ideas to better integrate their used social networks into these discussions. The buddy list as well as other social network services should be displayed on any device in the same manner as on the PC (m36, higher technical expertise, couple with children). One participant explicitly requested a functionality, where he could see what video content other friends were watching at that moment. He wanted to be able to switch to the same content and chat with the friends while watching the same thing (m37, higher technical expertise, couple without children). This topic triggered a critical discussion because the participants only wanted to be able to involve a small group of their entire buddy list: "[...] what I watch on TV [I only want to show] to people that I know very well" (m36, higher technical expertise, couple with children). In this context it could be interesting to be able to build groups to which specific friends can be assigned, since, for example, not all friends are interested in the same series (m37, higher technical expertise, couple without children). One of the participants noted that he only wanted to involve "[...] other persons [within the social network] who have the same interests and perhaps watch the same series and then talk about it" (m36, higher technical expertise, couple with children).

Another relevant topic within the workshops were recommendations of media content. Certain participants recommended TV series and YouTube clips to friends (e.g. m36, higher technical expertise, couple without children). Especially TV series in English, available only on the Internet, are shared and recommended between certain participants who know each other. While recommendations to others are mostly given in person (e.g. on the phone), online forums are used to search for hints from others: "[...] what do others say about that TV-series [...] does not always fit but very often" (f34, minor technical expertise, couple without children). An integrated rating process should allow for distinguishing between ratings from private and global communities because on the one hand the referrals of friends are higher rated as they are personally known, and on the other hand the global community provides a larger quantity of recommendations and reflects a broader opinion. One participant also suggested giving automatic recommendations based on his individual viewing patterns, on the viewing patterns of his friends as well as on public TV ratings (m36, higher technical expertise, couple without children). The discussion about how to give and read recommendations showed again that users should decide on their own whether that information is to be displayed on TV, smartphone or other devices.

In the workshop we also discussed a better integration of additional web-based services for retrieving additional content information. One of the participants mentioned that he would like to be able to decide for himself from what sources he obtains such additional and detailed information (m36, higher technical expertise, couple with children). Another attendee said that it would be interesting if content related information was provided automatically without entering an additional search string: "I don't want to have to search for it [the current TV/video content] on Amazon again, it would be better if it were possible to reach the corresponding page directly" (f41, minor technical expertise, single with children). For several participants context information that is related to the current scene of a movie, e.g. the current song on the soundtrack, actors in view or brands of items shown, is also of interest. Relevant information services that should be integrated are Wikipedia, Google Maps, iTunes, communities like Facebook or Twitter and fan-pages of actors.

5.6 Discussion

In the first part of our pre-study, we explored the current media usage of several devices in order to understand the established habits. The results show that even if used on different devices, various online and offline media are used simultaneously or in reference to each other. We identified a behavior that we call 'cross-media jumps'. Such jumps occur on one device, e.g. when users of a media center system switch between broadcast and online mode, and also between different devices, e.g. when a laptop is used simultaneously. Jumps between the available media are motivated by different reasons. For example, if the media on one channel is boring, an incoming message or phone call can be more attractive to the user or the watched content prompts him to search for additional context information on the Internet. Based on those findings several mock-ups were created that support such jumps in a smoother and more integrated manner, e.g. by offering an ad-hoc chat room related to the TV show on the mobile phone.

Before presenting the mock-ups, we started the workshops in a very open and creative manner. Here we identified needs towards an integrated and TV centered media platform that is accessible on several devices and individually configurable. The requirements for a universal access on different devices affirm earlier results from Obrist et al. [134] and Tsekleves et al. [146]. Content needs to be shared and accessed between personal and shared devices. By focusing on the social aspects, we also identified demands regarding a more integrated solution. A flexible overall platform as described by Cesar et al. [34] and Martin and Holtzman [120] seems to be a good starting point for exploring more specific aspects in detail. In one case, a participant wanted to have messages displayed on the television screen, while the particpant's partner asked for personal output that would not distract the TV reception. The preference for a favored solution is not triggered by personal needs only, but is also influenced by the social dimension of the television as a central, shared display in the home. Within our study, we identified several subtopics that are of importance, including private vs. shared notification mechanisms, context-based recommendations, flexible and personalized decisions about the devices for content input and output as well as related service source integration. Further systems should be designed as flexibly as possible, so that users can customize their media and information access to their own preference and also include settings for social intercommunication.

5.7 Implications for design

Video and TV content can be accessed on-demand by devices with increased Internet capability. Although this trend accomplishes an extended and flexible access to various online media and services, we are still facing some issues, which have been barely considered yet. During the use of a specific device, different content can be generated, such as pictures, videos, TV-recordings, documents or bookmarks. Usually, this content is stored on the device itself and cannot be accessed from other devices without further ado. This also applies to user settings and configurations, so that each device has to be set up individually. Consequently, we identified the requirement for a universal access on all used devices that also coincides with earlier findings from Obrist et al. [134] or Tsekleves et al. [146] – content needs to be able to be shared and accessed from different devices. Additionally, an infrastructure should enable users to customize and adapt the system to their own needs [159].

Cloud services like Apple iCloud or Dropbox address this issue. These services store the users' content on web servers and push it to other devices as soon as they have an Internet connection. However, those services are being repeatedly criticized due to privacy and security issues (Dropbox). Users have to hand over the control of their content to the cloud service provider and have to trust them to be responsible in handling their private files. Another issue with most of these cloud services is that data has to be transferred via a remote server, even though the content is usually requested from within the local area network (LAN). With respect to current bandwidths, the access to the content is accompanied with needing enormous amounts of time to receive the content on the device. To overcome this flaw, Dropbox came up with an option named 'LAN Sync', providing the possibility of synchronizing content between devices locally through the LAN connection. But still, the content first has to be uploaded to the server and be indexed, and then the local synchronization can be initialized. This procedure greatly reduces the downloading phase of the synchronization, but the duration of the uploading phase remains the same. Considering the fact that most domestic Internet connections have very limited upload rate, this option can not be considered as an effective solution for the problem.

Furthermore, there are approaches challenging the issue for a universal access within LANs. UPnP, DLNA, or AirPlay define architectures for providing, controlling and rendering audiovisual content. Media files are usually stored on a PC or network attached storage (NAS) which can be search with a media controller (e.g. smartphone). Users can browse through content stored on the server and send the files they want to play to an available media renderer (e.g. TV) in the LAN. In contrast to cloud services, content can be accessed fast and remains in the users' authority, as it is stored locally and not on a remote web server. Other than that, it is not possible to use these services from outside the network and it is also not possible to share user configurations between different devices, as the services are limited to multimedia content only.

Another requirement we identified during our study is a more integrated cross-devices usage. A good starting point for exploring this issue was described by Cesar et al. [35] and Martin Holtzman [120]. The synchronous usage of various devices as well as the fact that some devices are shared with other members of the household, requires a more flexible configurability regarding the access of content and services. The user should be able to decide what information is to be displayed on which device.

For instance, a user is watching TV and simultaneously chatting with his girlfriend. Since he is alone in the living room, the chat dialogue is displayed directly on the TV-screen. Then his sister enters the room and joins him. The chat, however, is private and not meant to be read by her. He should now be able to move the chat to a private device (e.g. smartphone) without interrupting the conversation. It is also imaginable that the user can decide for each single piece of information on which screen it should be displayed. So, while the chat dialogue has now been moved to the smartphone, the buddy list or notifications about new messages remain on the TV screen.

5.7.1 SocialMedia framework

In a first step we designed an integrated framework to accomplish the fundamental requirements including universal access, social exchange and flexible cross-device usage (see Figure 18). The basis of our approach is a central web server for managing user profiles, the conjunction of the different devices and also the integration of existing web-based services and social communities. As the basis for the current server implementation, we used the open source social networking engine Elgg that has all the attributes necessary to set up a custom social network. Additional servers are located in the users'

Figure 18: SocialMedia Framework

households, acting as local private clouds where the users' content is stored. The advantage of this approach is that the users keep control over their data, as it is physically stored in their home. Each local server is connected to the central web server, so that they are also reachable from outside the home and in addition it makes cross-linkage between different households possible.

The SocialMedia framework will be used as basic infrastructure for further enhanced Social TV concepts. Limitations of early approaches, e.g. all content displayed on one device, will be overcome by more flexible options to choose from. While television and video content can be accessed from different devices and individually enriched by social functionalities, the connection between public displays (e.g. TV) and personal devices (e.g. mobile phones) can be realized in a smoother and more interconnected manner. The variety of mobile platforms should not be regarded as a barrier for development. There are several fully developed solutions we can use that make it possible to just have to code once and then be able to deploy new applications on multiple mobile platforms, such as PhoneGap[3], or Mono[4]. This approach not only reduces the work load of developing for each platform, but also ensures a cooperate design to provide consistent user experience between platforms. In our project we will realize use-cases that take advantage of this integrated, cross-platform architecture. In the following chapters we will present two use cases that show the potential of more flexible scenarios.

Use case I: TV bookmarking The parallel usage of different devices during TV consumption was identified as a common pattern in our study. In many cases the content consumed on the additional devices had a relation to the content watched simultaneously on the TV, e.g. checking the TV guide, looking up information on the actor, or opening a web link just seen on TV. This so-called 'additional information' searching is an iconic media consumption activity on additional devices. Nevertheless, for those who did not use additional devices, the media-center PC was used to search for additional information during commercial breaks.

In this use case we have taken advantage of the integration of different devices, granting a seamless content flow between devices to obtain additional information. A TV bookmarking concept has been developed to save the information on the TV content and to be able to access it later from anywhere.

Peter is watching news on TV together with his wife and children in the living room. The news has mentioned a very advanced coffee machine. Peter finds it interesting, but is reluctant to interrupt watching TV to search for further information. He clicks a button on his smartphone and a TV bookmark together with a short clip from the current TV program is recorded and saved for him. A few minutes later, the news shows something about a famous actress. The family is a big fan of her, so they talk about her for a while. Peter wants to show some clips from her films to his family. He searches the Internet on his smartphone and finds a video clip from one of her famous movies. He then 'sends' the video to the TV through a finger slide on the smartphone. The family watches the video together on the big screen and enjoys it. The son thinks the video is so cool that he would like to show it to his friends the next day. Through a finger slide on his own smartphone, the video is 'fetched' and sent to the son's own mobile device. The next day when Peter was going to work by tram, he suddenly remembers

[3]PhoneGap. The only open source mobile framework that supports 7 platforms. http://phonegap.com

[4]Mono. Cross platform, open source .NET development framework. http://mono-project.com

that there is a new coffee machine that he would like to know more about, but he can't remember the brand. He then checks the video bookmarks on his smartphone and watches the video clips, which were automatically recorded, from yesterday. In the video, he sees the brand of the machine and then he looks it up on the Internet on the phone to receive more information on the performance and price of the machine.

Use case II: Cross-device recommendation In the next use case we will shortly describe an approach for a cross-platform recommendation system based on the users' individual viewing behavior. For this, we took advantage of the integration of different devices and a universal access from any place. The user's viewing behavior on every device will be gathered and analyzed as a whole, yet data security will be treated carefully. Universal access will provide users with a high degree of freedom to seamlessly consume the content on any device.

Peter watches his favorite TV show every Tuesday at home. Unfortunately, he has to work longer today and he will not make it home on time. Five minutes before the show starts he gets a notification on his smartphone that reminds him that the show is about to start.. As he has no opportunity to watch it, he presses the 'record' button on the phone and his TV at home immediately starts recording the show. Two hours later, when he finally arrives home, he is glad to be able to watch the recorded content. A week later, Peter is stuck on his way home via train because of a disturbance. Once again he will not make it home in time to watch his show and again he receives a notification five minutes before the show starts. As he has nothing to do right now, he presses the 'watch now' button and his TV immediately starts to stream the content directly to his smartphone. Subsequently, Peter starts to pay attention to what interesting movies are being shown soon on TV. Based on Peters past viewing behavior and the viewing behavior of others, his smartphone automatically recommends movies to him that he might be interested in. Several days later, during the evening, after dinner, Peter sits in the living room with the family. While hesitant about what to watch, Peter happens to receive a film recommendation from his best friend Mark on his smartphone. He knows that Mark has a similar taste in movies as him, so he presses the "watch now" button and then chooses to play it on the TV. After 10 minutes he realizes that the other family members don't really enjoy the movie as he does, so he switches the movie playback to his laptop and continues watching from there, allowing the other family members to watch something else on TV. Peter knows that Mark is also watching the *movie through the awareness function on the platform, and chats with him once in a while about the movie, while watching it.*

5.8 Conclusion

The way of accessing video and TV content in a flexible manner and also the way of communicating about such content remotely has influenced the current practice. A more comfortable behavior has becomes especially visible in cross-platform usage that is characterized by a flexible access to content and communication options on different devices. The usage of different devices and services from different sources has become more and more interconnected. In order to support this trend, devices have started to have extended functionalities, which leverage the functions of the others, for instance, being able to watch TV shows from online portals on the PC. On the other hand, different devices supplement each other in an even greater extent, e.g. using the smartphone as a remote control for the television. However, current approaches support identified needs only partially. We have developed a SocialMedia framework as a basis for further, more integrated concepts. This framework aims to overcome the limitations of isolated solutions and provide a basis for enhanced Social TV functionalities.

By exploring current practices, we gained insights into the interplay of television, PC and mobile technologies in domestic environments. Participants in our study requested for more integrated concepts that guide users to interesting options in a smooth way, e.g. by linking to related information. Additionally, an intuitive interface concept is necessary that has a similar look feel on different devices. Concerning such device-bridging approaches that are characterized by more integrated services, many issues regarding valuable concepts in an interconnected Social TV environment need to be addressed. By describing concrete use-cases, we want to highlight the potential that more integrated concepts can provide. TV bookmarking and cross-device recommendations are two examples, of how to make value of an interconnected infrastructure as presented by our framework. Further work needs to address the concrete implementation and the influence of such tools in the social practice.

6 Expressing use: infrastructure probes in professional environments[5]

Abstract

Cultural Probes have proven to be a successful approach for involving end users in exploring the context one might design for. Several studies made value of probes in domestic contexts to inspire the design of systems but the role of probes in business contexts is underexplored. In this paper we report on our experiences of adapting probes to be used as a method for a user-centered design process in work environments. Our probes, called Infrastructure Probes, are tools for self-documentation and reflection to enable employees to document usage, problems and suggestions related to their IT and workplace infrastructure. We evaluated the Infrastructure Probes in two field studies. In this paper we motivate the approach, discuss values and issues by introducing probes into a business context and reflect on the lessons we learnt.

6.1 Introduction

In previous works [46] we focused on the design of software systems for Small and Medium-sized Enterprises (SME) which can easily be adapted by users themselves. We were interested in the existing practice of end-user activities, e.g. in relation of how they adapt the IT infrastructure, how they report and resolve technological problems and how they communicate work arounds. The practices we were interested in are incident-based ones, only weakly routinized and regarded as peripheral to the 'actual, productive work'. Even if ethnographic methods are being widely used in user-centered design processes to provide a rich picture of the work environment, the contextualized feedback we are interested in is difficult to explore this way.

Apart from ethnographic methods (e.g. observations, surveys, interviews) "Cultural Probes" [66] has gained scientific interest within the past decade. The approach introduced by Gaver et al. and in meantime adapted in several studies [26], can be characterized as an explorative self-reflection method that enables users to provide open and creative forms of feedback from the context in question. Probes usually consist of several tools that

[5] This chapter has been published as an paper in the proceedings of International Symposium of End User Development (IS EUD), 2011: Hess, J., Doerner, C., Pipek, V., and Wiedenhoefer, T. (2011): Expressing use: infrastructure probes in professional environments. In Proceedings of the Third international conference on End-user development (IS-EUD'11), Springer-Verlag, Berlin, Heidelberg, 301-306.

enable participants to capture their environment and also to express their feelings and wishes, leading to a documentation of their context. These properties make probes unique in a sense since they easily allow capturing information about the researched context without distracting people too much in their environment.

Although probes were introduced to inspire the design in domestic contexts, we were interested to see if they can also be adopted for professional settings to get insights into work contexts. There are a few studies of probes for business contexts. Jäsköö and Mattelmäki [104] adapted the probes concepts to gain an understanding of routines and actions of nurses. Lucero and Martens [117] used probes as a first ethnographical part for identifying design activities that can be supported by mixed reality. In [118] Lucero and Mattelmäki describe an approach they called 'Professional Probes'. In their work they reflect their findings gathered with industrial designers. They spent a considerable amount of work and resources in creating their probes. However, they identified several problems of using probes in a professional context. Several participants dropped the study while mentioning a lack of time for the documentation process. For some attendees the probes study also turned into an obligation they had to do.

In our research we also adapted probes to a business context. While conducting standard ethnographical methods for the overall research project [46] we experimented with the probes in addition to gather own hands-on experience and to put the focus on activities related to end-user development (EUD) [114]. Our work is motivated by the question to what extend a probes design can support empirical exploration of the current EUD practice. Such practice, e.g. customize a module to reach a specific goal, would not only be of interest for us as researcher but also of interest for the employees within the same company, e.g. by sharing such documentations with each other. In order to reach those goals, our probes approach is a combination of physical artifacts, such as cameras and a 'Technology Probe' [102] which we realized as a snapshot tool. Such a technological probe combines "... the social science goal of collecting information, the engineering goal of field-testing the technology, and the design goal of inspiring users and designers..." [102]. We studied the Infrastructure Probes in a real world context, by involving five small- and medium-sized companies in our study. Based on this broad practical setting, we are able to report on the lessons we learned and will also draw some valuable conclusions from our work.

6.2 Concept

Methods for End-User Development (EUD) enable end-users to get actively engaged in adaption and development of information systems [114]. Our so-called Infrastructure Probes (IPs) are intended for self-documentation and reflection on problems and use innovations in the everyday practice of the employees. The IPs should enable participants to help each other and to improve their working infrastructure. Since users may be good at solving the problems they have, but not at documenting how they did it, the Infrastructure Probes should help them to simplify this process. The Infrastructure Probes help users to structure their documentations, making it easier for others to understand them. The arrangement of the IPs targets the documentation of usages of IT infrastructures. Their design is theoretically informed by research on E-Infrastructures as described in [169]: The IPs specifically aim at documenting 'infrastructure breakdowns' and 'use innovations'.

Our Infrastructure Probes are an arrangement of different probes/tools to enable users to "self-document" their environment (see Figure 19). The IP package should attract users in different ways depending on their skills and knowledge. All probes are quite simple to understand, making sure to get as many users involved as possible. The following collection of probes is contained in the IPs package: A digital camera (Figure 19, 2) can be used to reveal problems that are not restricted to software alone (e.g. if the transfer of data between two applications is done by paper documents). The Post-its (Figure 19, 3) can be used to take down short notes or to "highlight" specific things in a picture. The forms (Figure 19, 4) are designed for a structured description of problems and problem solving strategies. The IT diary (Figure 19, 5) has two functions: First, it offers an unstructured way to document problems and problem solving strategies. Second, it allows participants to put documentations which have been made with different probes in a connected, chronological order. The writing pad (Figure 19, 6) can be used for the creation of paper mock-ups. We also added a user manual (Figure 19, 7) that describes the function and possible usage of each probe. Our 'Technology Probe' [118] – a snapshot tool (installed on the USB-Stick shown in Figure 19, 1) – is considered to be the most important probe of the package because it gives users the chance to create, annotate and manage screen shots. The annotation of the screen shots is important, as it allows users to provide more detailed context information about the problem at hand.

6.3 Evaluation

In the first evaluation of the Infrastructure Probes we basically aimed to answer the following questions. First, what is the general perception of the usefulness of the probes in the work context of each participant? Second, what kind of problems did the participants record? Third, in which way were the probes used? Forth, how can the quality of the problem descriptions be evaluated and fifth, how usable are the probe tools. We created twelve IPs packages with the previously described set of different probes. The packages were given for eight weeks to twelve participants working for five different SME. We gave each participant a short oral introduction, telling her or him about the aim of IPs and about the possible usage of each probe. After the first third of the eight-week trial, we interviewed the participants via telephone to get first impressions about their experiences with the IPs. At the end of the trial, we analyzed the data and organized feedback workshops together with the participants to discuss the results and ask them about their experiences with using the probes.

For the second evaluation we gave eleven participants an improved version of the IPs. Regarding the IT-diary, the Post-it's and the forms, participants from the first trial noted that these probes were too bureaucratic and required too much time to be used properly. For these reasons we didn't use these probes in the second evaluation. The digital cameras from the first phase were used again. One of the major improvements concerned the snapshot tool. According to the suitability of the users' tasks, we integrated an email function which enables users to send screenshots to other persons. Collaboration among employees would be possible this way, e.g. by tailoring artifacts [138] and documenting of the adaption. This time, only four of the five companies of the first evaluation participated. Based on our experiences, we demonstrated the use of the snapshot tool and the other tools during the introduction and also gave participants the chance to try each of the probes. After several months we end up the evaluation by interviewing nine participants separately to get more detailed information about their experiences with the probes.

Seven out of 11 participants used the IPs in the first evaluation. Table 1 provides an overview of the collected data. Instead of using our tools, three participants used an alternative documentation method. They took screenshots and copied and pasted them into Word documents. While the snapshot tool was used by some of the participants, the IT diary and the writing pad were not used by anyone and only two persons used the forms.

The camera was primarily used to document participants' workspace.

Figure 19: Infrastructure Proes

Feedback	Quantity
Pictures taken by the camera	26
Screenshots taken by the snapshot tool	11
Screenshots embedded in WORD documents	17
Handwritten notes	5*

Table 1: Quantitative overview of the feedback (*notes include forms)

In addition, one of the participants used the camera to take photos of her screen. Her pictures showed different dialogs which were related to driver problems and error messages. She also tried to describe her problems by using the forms. Four persons used the screenshot tool as intended by us, providing a rather rich documentation. Three of these participants worked for the same company where a culture of documenting problems and solutions (with another screenshot tool) was already established. These three participants made screenshots of the applications and used the tool's annotation functions to describe their problems. For example, one of the participants took a screenshot of an order document in his SAP system and described it as "Transfer of supplier master data". He also added a complaint: "[...] the current master data of the supplier is obviously not transferred" by using copy-and-paste which could lead to a wrong address on the order document. In the comment field of another screenshot he extensively described problems that can occur in the case an article is "locked".

The second phase with the modified approach did not lead to the expected adoption of the IPs. Instead of using the Infrastructure Probes, one participant used Microsoft Excel to describe his problems. Within his Excel sheet, we found problem descriptions with Microsoft Office applications, general software errors and difficulties with SAP software modules. Another participant, working in quality management, claimed that they already use a snapshot and reporting tool to indicate and describe product shortcomings and problems.

To get detailed information about the acceptance/non-acceptance of the IPs and to reflect on the method, we conducted telephone interviews and feedback workshops. The majority of the participants said that they did not use the probes because they did not have enough time during the day. The use of the probes seemed to be too time consuming and too difficult to incorporate into the daily work routine for most participants. In case problems occurred, participants stayed focused on the resolutions of these problems and did not think about using the Infrastructure Probes to document these processes. Another important aspect for not using the probes was the fact that most users considered the IPs as a "job" which had to be done in addition to their regular work and not as a useful extra task that could stimulate collaboration to improve the IT and workplace infrastructure.

Technical problems also lead to the fact that participants refused to use the probes. The participants from one firm did not use the snapshot tool because of policy constraints from the IT department. In the first evaluation two participants also had problems in using the USB sticks with the snapshot tool. However, according to the majority of the participants, the snapshot tool had been the most interesting tool in the probes package. In the feedback workshops, participants suggested improvements for the snapshot tool. They showed us typical work processes where they printed documentations or help instructions that were kept in folders. To enrich these documentation processes, a print functionality should be included in the snapshot tool as well as the option to create a series of screenshots. Additionally, a faster and easier-to-use interface was strongly demanded. Especially for users with less technical knowledge the tool was not as easy to use as it should be.

6.4 Conclusion

Our research was motivated by the necessities to find efficient means to capture an incident-oriented, weakly routinized and peripheral work practice (coping with workplace infrastructure breakdowns and innovations). Participants who used the Infrastructure Probes gave us concrete examples of breakdown situations which we could discuss later on in more detail. These examples were helpful for us because we could not identify them in the interviews that we had conducted before. The method worked – at least for some users – as intended by us. Participants informed us about their work environment and problems with the IT infrastructure. From this point of view, the Infrastructure Probes can add value to other empirical methods. However, in our evaluation of the Infrastructure Probes we also identified different aspects that make it hard to use them in business contexts. For the participants it was difficult to integrate them in their work practice, time constraints also did not gave enough space to use the probes as intended by us.

The Cultural Probes are well-designed artifacts that stimulate use. Lucero Mattelmäki [118] recommended adapting them to a fluid and playful process to avoid obligation. In contrast to this, our Infrastructure Probes are less playful, although we tried to integrate some 'funny' things in the packages of the second study, such as comics, mouse pad, emoticons within the snapshot tool. Maybe we would have gotten better results if the probes had been more attractive, for example by using better designed material to stimulate creativity. However, the Infrastructure Probes needed to be balanced out between a creative or even playful [118] motivation for using them (that still has to done by further improvements of the design) and a 'serious' motivation of getting something in return (e.g. help, documentation of problem solutions). In addition, we consider the first confrontation of users with the Infrastructure Probes is a critical point for adoption. The reason is that we saw the strongest interest of participants in the first evaluation which means that the initial try-out experience of participants is very important. In the long run, the fact of having a personal benefit from using the probes becomes more important.

7 In-situ Everywhere: A Qualitative Feedback Infrastructure for Cross Platform Home-IT[6]

Abstract

The domestic appliance landscape is becoming increasingly interconnected with different options to consume rich media, e.g. on TV, PC or Mobile with manifold options for additional services. From a participatory design oriented perspective, involving users into the design of new applications related to video and TV is a topic with growing importance. However, current options to provide feedback at use-time are limited to a standardized form, e.g. in traditional usability tests. In order to open the design space for long-term and more creative in-situ feedback, we will address this topic by a concept of a cross platform infrastructure that enables users to provide feedback on different devices in the context of the usage. This concept enables users to co-develop and improve a system over time in a continuous manner. Crossing the boundaries of various platforms, feedback can be enriched in a very comfortable way, e.g. by annotating a screenshot of the television screen with the smartphone.

7.1 Introduction

Since many years, research has been putting a strong focus on involving users in the design process of new applications. Including employees in the design of computer systems as they are being developed [24], has its origins in Scandinavia, and participatory design (PD) also became important in domestic contexts. Previous work has put strong focus on real life contexts, with PD variations used for evaluation and exploration. 'Cultural probes' have been used to explore this approach in order to gain new ideas for improvement. Bernhaupt [15] for example created and tested the 'playful probes' – a collection of games and playful material aimed at encouraging user involvement. Other works focus on the question of how to evaluate new prototypes and how to improve usability along design guidelines [14, 68].

In our previous work we gave insight into how users could be involved over longer period of time, in order to collect new ideas and be able to improve functionalities continuously. Our previous experience with community driven development [86] has shown that feedback channels should be

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integrated directly in the artifact. Instead of only discussing new functionalities in an online forum, additional channels should enable users to provide feedback directly in the context of the usage. Such functionality should go beyond a simple error reporting system and give options to explain desired improvements through visual descriptions, e.g. by annotating a snapshot of the TV interface on the mobile device.

In a running research project we are developing a cross platform framework for the home entertainment domain to support the exchange of audio/visual content between different devices and to enrich this with community functionalities. From an empirical point of view, we have observed different kinds of usage jumps [89] on a single device (e.g. switching between TV and Internet module at the media center system) and between different devices as well (e.g. searching for additional content on the smartphone while watching TV). In order to support such behavior, services need to be adapted for the specific context, e.g. on a public screen or on personal devices. PD oriented work and concepts for remote evaluation may support the design process with adequate services for remote user participation.

Providing feedback on public devices, such as the television set, can be tricky. Normally controlled via remote control, the TV provides only limited options to enter text or highlight certain screen area. While designing for a cross platform infrastructure, we also scaled the feedback-issue on that level. It means that the users should be able to generate in-situ feedbacks on any device and annotate it easily with another one, e.g. capture a screenshot on the mobile device and edit it on the tablet. Options should provide the users with possibilities to enrich screenshots and photos with text, audio or other descriptive elements. The feedbacks then can be made available for the developers and other users as well, e.g. in an online forum. This opportunity would empower users to articulate their needs much easier and much clearer, which in turn makes it possible for the designers to understand the context much better.

7.2 Context motivation

The digitization of the media scene entails far-reaching changes in domestic appliances and information technology. More and more devices such as the television are being equipped with computer technology thus offer diverse additional functions because of their network capability. Full-video content is available on demand and in a nonlinear fashion in different contexts. In our research project SocialMedia we will take these developments into account by exploring new integrated techniques and concepts for cross-platform communication and exchange between users. Therefore, we focus on a dynamic home-IT infrastructure, in which the TV or the media center PC is an important component. We are particularly interested in concepts that support social exchange with regard to full-video content.

User participation in the design and evaluation process has an increasingly important impact on innovative application development [24]. The SocialMedia project has been following the participatory design principle right from the start. A Living-Lab consisting of 27 participants from 16 households has been established in the early stages of the project [91] and design and development has taken advantage of the long-term test studies from the Living-Lab. From the methodological point of view, long-term co-operation with testers requires a specific methodology toolkit that should include standard approaches (e.g. controlled lab studies or media diaries) and customized feedback tools as well. While we used both former methods in certain stages of the project (e.g. creative workshops with groups of participants, usability studies in controlled lab environments), we were also confronted with the need to involve participants in a more continuous way, in-situ at home. This was requested by both the developers and the users. Developers wanted to have feedback channels that were built into the prototypes they developed, in order to receive feedback directly from the actual context of use, so that they could understand the problems better and come up with solutions faster. Users wanted to have easier options to exchange their user experience with other users from the test group in order to help each other in the process of appropriation. Unlike any full automatic bug tracking system, our feedback infrastructure presented in this paper suits the best in a long-term qualitative research methodology. The motivation is to use feedback as a trigger for later discussion between developers and users. The developer will always contact the user and refer to the feedbacks together to help both parties understand the problem better, in this sense the users are able to "co-develop" with the developers.

Within the current development status of the project, we have built an alpha version of a social TV application running on the media center PC which is connected to the television screen, a mobile application running on Android powered gadgets, and a social platform on the web. The motivation of the feedback architecture described in this paper is to provide feedback channels for the interconnected application components during the design phase, so that the developers are able to gather first-hand user needs with preserved context in order to re-design the current (basic) version, as well as gather new ideas for further releases. On the other hand, such tools are important for the users as well to be able to support the appropriation of new applications by providing integrated help channels.

7.3 Previous work

From the literature there are different methodological approaches to empower the user to report usability and user experience aspects from the real usage context. When studying user interaction with a system imbedded into their real life usage context, in-situ studies are appreciated for its directness of feedback and preservation of the exact context [188]. As shown in the work of Obrist et al. [167], an in-situ field study is best suited for real usage context and actively engaging test sessions. However, it requires the developers to be synchronously and physically beside or next to the users, as direct communication between stakeholders is seen as key in this approach. The session is relatively action-intensive; this makes it difficult to apply this approach to a long-term evaluation.

While users and developers are involved in different Communities of Practice (CoP), there is a gap in the sense of time, space, and culture between both stakeholders [183]. In order to support the appropriation of new functionalities, tools for remote evaluation can also be used for remote participation between participants as well. Members of the community can be empowered to "help themselves" with issues and problems. Another quite important focus of using online technologies in participatory design projects is the definition of new product requirements through members of the community [86]. Online forums, wikis and options to provide feedback in-situ (here implemented as a voting function via TV) enable members of an online community to discuss and decide on their own, which functionalities are important.

Remote evaluation is a well-accepted method to overcome the limitation of distributed locations of users and developers. Different mechanisms can be used to support exchange between users and developers via audio and video. Such remote evaluation (e.g. semi-instrumented remote evaluation which features asynchronous information exchange) is quite interesting for us, although a brief training for the users is necessary to be able to identify and report the critical incidents [80].

Also relevant are previous workings on Technology Probes [102], Mobile Probes [99] and Infrastructure Probes (IPs) [88]. While mobile probes help to explore the mobile context in question for studying people's actions, technology probes are technical artifacts with the aim to evaluate a technology additionally. The aim of the IPs is close to our work and is theoretically informed by research on E-Infrastructures [170]. The IPs specifically aim at documenting 'infrastructure breakdowns' and 'use innovations'.

While services are becoming more and more interconnected with each other, with adequate interfaces on each device, this should be considered for concepts for distributed user participation. Optimally, meta-tools can be used in an open and more creative phase of design exploration and in a more structured feedback phase for evaluation as well. Compared to previous works [86, 99, 102] we have addressed a feedback concept that overcomes limitations of separated solutions. Ideas, improvements and breakdowns should easily be captured in context of use, accessible and annotatable from any other device with the easy options to share.

7.4 Cross platform feedback infrastructure

One major problem when testing early stage prototypes in real world contexts is to identify and report critical incidents during usage. Current approaches only concern themselves with specific use contexts and devices. However, lots of applications are developed for multiple devices and in addition to the mobility of devices such as smartphones, tablets or laptops, users are able to switch their spatial usage context. In our concept, we will focus on a cross platform solution, which enables users to capture their current usage setting on any used device and in any usage context, regardless of e.g. whether they are at home watching TV, on the move at the train station or at work, while surfing the internet.

For an optimal specification of critical incidents, and to avoid forcing users to interrupt their workflow, feedback should be created directly from the main application without the need of leaving the usage context. The effort necessary to create a new report should be as low as possible. To simplify this process, we want to benefit from the devices' multimedia interfaces that allow the user to enrich feedbacks by various multimedia contents. Besides simple text messages it shall be possible to attach different types of images; like screenshots or pictures taken with the internal camera of a smartphone, or sketches. Furthermore, videos and audio recordings are helpful in enriching the feedback with meaningful information. This flexibility of being able to choose between multiple input options also has an advantage in regards to the limitations of input options on some devices. Text input, for instance, can be tedious on the smartphone thus voice recording might be a more comfortable option.

In addition, it would be helpful to be able to create and edit feedback on multiple devices. For instance, when using an application on the television, a screenshot of a critical incident can be captured, but making further

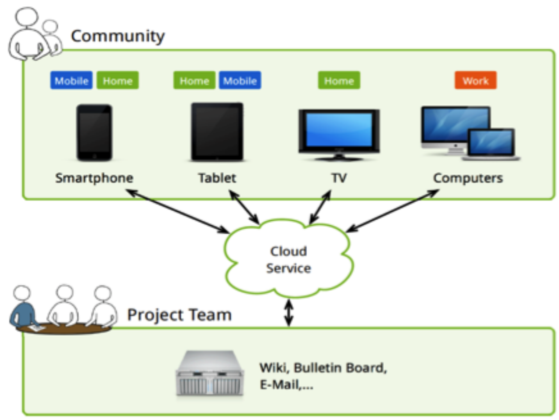

Figure 20: Cross Platform Feedback Infrastructure

text annotations or sketches is not possible on this device due to interface restrictions. Hence, the user should be able to switch to another, more suitable device and complete the report there. To make this possible, reports have to be stored temporarily on a central storage unit, where they can be accessed from any device. Besides, depending on the users' context, creating detailed feedback is not always desired or possible, e.g. due to lack of time. In that case, it is helpful to save a report and then complete it later. When a feedback report has been completed, it will be sent to the feedback pool. A forum manager filters the feedback in the first round, picking out those feedback that could advocate discussion within the test group and posts them in the forum of the community portal. Descriptions of problems, issues and improvements can be forwarded to the developers. The developer, or other representatives from the project team, can also contact the user and discuss the feedback with them together, referring to the feedback as a memory cue. In this sense we motivate the users to "co-develop" with us through the design process.

Another relevant kind of feedback we are dealing with is the feature request. Due to the strong involvement of users in our design processes, suggestions for additional features will and should be made continuously. These requests can be created in a similar way as a bug report and then submitted to a community portal. This way, the members of the testing community have the opportunity to discuss the submitted feature requests, rate them and even enhance them to participate in the further development.

The overall concept of our cross platform feedback approach is shown in figure 20. Users from a testing community can create bug reports or feature requests on any device they use. To enable a cross platform editing or a subsequent editing, feedbacks are temporarily stored in a central cloud service, where they are accessible from any device at any time. When a report is finished, it will be sent either to a developer platform or a community platform for further discussion. A back channel allows for continuously status request both for the developers or the users.

7.4.1 Feedback app

The implementation of the feedback system is highly modular and extensible. The feedback component on each platform can be developed independently and then easily integrated into the whole infrastructure. Starting out, we discussed several options and decided that a feedback tool on a mobile platform should be the first step to the whole system. A feedback tool on a mobile platform can be used in a very flexible way to cover the other platforms when their native feedback counterparts are still in their early design phases. Using the built-in camera of the mobile phone, the user can easily take pictures of the interfaces of the project prototypes on other platforms, e.g. from the sofa and capturing the TV interface. In this way, cross-platform feedback composing can be achieved in a temporarily compromised way. The second reason is due to the different progress of the prototypes development in the SocialMedia project. The mobile application in the project has been the lead in the development compared with the TV client and web client, a feedback tool on the mobile platform to keep pace with the prototype development was then part of our consideration.

In the stage we are currently in, we have developed a feedback tool for the Android platform, which will be delivered together with the project mobile app for user evaluation. Figure 21 shows the user interface and an example feedback report. There are 3 ways to launch the feedback application. It can be started just like any other Android applications and this is meant for casual feedback composing, editing, or browsing. The user is also able to take a screenshot directly in the project mobile app by pressing a key combination of “Menu” and “Search”. The feedback app will then automatically open and generates a new feedback report using the screenshot. This method is mostly used to capture use context directly from inside the mobile app. The 3rd method starts with a normal camera capture, the user can then send the photo to a list of applications that is shown to him when he opens the picture from the device’s photo gallery. When the user selects the feedback app to receive the photo, the app will be launched and a new feedback report will be generated using the photo. This method is mainly designed for capturing

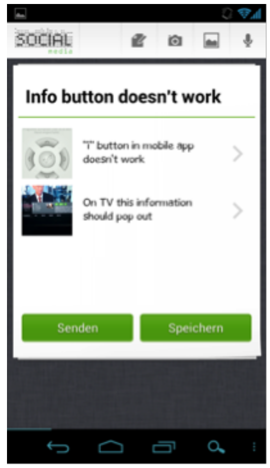

Figure 21: UI of the feedback tool on the mobile platform

photos of the other platforms.

The example feedback report in Figure 2 consists of a screenshot directly taken from within the project mobile app (in its remote control module) and a photo of the TV client. It was a complaint where, when the user pressed the info button on the mobile app, nothing happened on the TV client. The user was expecting the additional information panel to automatically pop up, so he manually opened the information panel and took a photo of it with the mobile phone to show the effect he would like to have. Each feedback is a combination of text comments, photos, or audio recordings. The 4 icons on the top right corner provide the user with the ability to attach this content to the feedback report. By choosing the send button, the current report is saved on the server's side. The designer can access the feedback and react, e.g. with adaptations of the software or by discussing the feedback in the online forum.

7.4.2 Towards meta-design variations

While infrastructure breakdowns and user innovations become especially visible during usage [170], our work is motivated by the need to involve users more in the design of their usage contexts and within development process. In order to support meta-design as proposed by Fischer [57], with tools that empowers users to continuously 'design' during use, we present the concept of a cross platform feedback infrastructure. It is designed to empower users to provide feedback directly from within the context of use, regardless of specific platform's limitations. The feedback can be sent to the developers for professional support, as well as to other users from the community, to take advantage of the collective wisdom.

For our further work we are planning to use the mobile feedback tool in combination with the project application bundle (the social TV application, the mobile application and the social network). We are aware of the current limitations, but we are able to support the feedback process at the current state. The concept of the cross platform feedback infrastructure can be used in various domains. Even though our current implementation is focused on functionalities that support the design process (e.g. reporting bugs or providing improvement suggestions), the concept can be further utilized for empirical studies, to explore the context in general (e.g. digitalized media diary). In our future work we are also thinking about adding more playful traits to the concept to better motivate users to participate, e.g. by earning badges or providing a 'tamagotchi' like interface.

8 Supporting End-User Articulations in Evolving Business Processes: A Case Study to explore Intuitive Notations and Interaction Designs[7]

Abstract

Adaptations of business processes are important in work environments, specifically when process-support needs to be tailored according to changing needs. The creation, the management, and the adaptation of process models require typically modeling-experts. While these actors are knowledgeable in formalizing and operationalizing processes end-users who do not necessarily possess sophisticated modeling skills know typically local practices and framing conditions best. In this paper, we present an approach to support users in articulating their needs and to involve them into the (re-)design of process specifications. We explore how end-users reflect upon and articulate about business processes. Based on results of a qualitative study, we present a new, paper-based interaction technique, which enables users with little skills to model processes. The resulting process specifications can be transferred either in paper or in digital form into traditional modeling systems for further elaboration.

8.1 Introduction

In today's enterprises, well-designed processes guide the creation of goods and services. For traditional industries that mainly produce for the mass market, an effective and efficient workflow management is crucial. The best practices emerge with time and process descriptions represent these practices on a formal level for decision, execution and analysis purposes. At the level of knowledge work, process descriptions also guide work practices, but are characterized by a less explicit and formalized representation. Requirements depend on the context, they often change, and this requires flexible adaptations of forms that have already been established. Such types of dynamic behavior can often be found in particularly small and medium sized companies (SMEs) that usually have to react to the changing market situation rather quickly. Even if those are not necessarily called process models, here employees execute work in a process that is learned, that is being prac-

[7]This chapter has been published as an journal paper in International Journal of Cooperative Information Systems (IJCIS), 2012: Hess, J., Reuter, C., Pipek, V. Wulf, V. (2012): Supporting End-User Articulations in Evolving Business Processes: A Case Study to explore Intuitive Notations and Interaction Designs. In: International Journal of Cooperative Information Systems (IJCIS) (ISSN: 0218-8430).

ticed, and that needs to be adapted and improved in order to be able to satisfy changing demands.

The knowledge about framing conditions and requirements for the processes often lies with several domain experts, i.e. end-users who are experienced in their area of work and act on practices established over time. In our work such domain-experts are referenced as 'end-users' with good practical experience but with no advanced skills in formal modeling. Usually, end-users understand the complexity of the process (in a sense of complexity of practice) but normally cannot influence change in the process model. Typically, the modeling process is based on complex notations and tools, which require expertise from the modeling experts. 'Modeling experts', are defined as users with the knowledge to operationalize and formalize the modeling, define and structure the schedule of work. Based on that expertise, modeling experts create (complex) models with (normally) complex modeling languages that end-users have to work on. In practice, gaps will evolve between the definition (the way how work should be done) and the practice (the way how work is done). In order to bridge the gap between modeling experts and end-users [55], we are interested in new forms of cooperation that require process notations and interaction concepts that are understandable and intuitively usable by all stakeholders involved. As a precondition, the process language needs to be easy to understand and intuitive to use.

Tools for business process reengineering, workflow management [153] or business process execution in Service-Oriented Architectures (e.g. Levardy and Browning [157]), form an infrastructure of process-oriented adaptive systems that usually require expert knowledge in their model management. Adieu [174] and SISO [49] are examples that support modeling with an easier to handle interface. However, as stated by Shipman Marshall [175], formal representations can be difficult to understand and can also be easily misunderstood by end-users. There is a necessity to express contextual issues through informal representations [48, 175] and while the limited space of a computer screen makes simultaneous collaboration difficult, pen-based systems [41, 187] provide an alternative to traditional input concepts. Participants can use different pens simultaneously and large sheets of paper provide an adequate backdrop for creating representations that include formal and informal elements [41].

In order to support collaboration and interaction, we have chosen to focus on a scenario, where the end-user and modeling experts share a common understanding by working on a reference, which is understandable and modifiable by both. As a scenario, an end-user wants to indicate that a current process needs to be adapted, e.g. because the business process pre-defined by the system requires work that can be done in a much easier way. When articulating such improvements to the modeling expert, a common language and representation will ease the cooperation and improve flexibility. By using pen and paper, the end-user can reflect on the processes, add alternatives to a standard process and add informal elements (e.g. comments). In our scenario the activities of such articulation work has been automatically digitalized and recognized by the system. The digital representation of the design sessions can be shared with other users, e.g. to add further information, and can also be used by the modeling expert as input for the design.

In two explorative studies, we have learned how employees articulate and reflect on their work practices with the help of conceptual modeling examples from their current business. Our empirical work mainly focuses on an explorative understanding of how end-users reflect on modeling and what the representation of processes designed by end-users will look like. From pre-studies of both cases, we have summarized the requirements for a more intuitive and easy-to-understand concept of how we can involve the end-user into the process design. As a first answer to the issues mentioned above, we will present an adaptive system that allows computer supported collaborative modeling with pen and paper. The resulting representation can be used as a shared reference, similar to a shared language in software development [82] that is understandable by different stakeholders. Modeling experts will get an understanding of current practices that can be supported with well-structured models and end-users can reflect on and improve the current work by expressing their needs.

Based on the design of an end-user modeling language (chapter 3), we will address the gap between formalizing and (re-)using the output, by following an adaptive approach based on digital pen and paper technology (chapter 4). This should support interaction between different stakeholders by supporting the recognition of formal and informal elements, by exporting into different formats and by providing a basis for (re-)using the boundary objects further. In the discussion (chapter 5), we further map out the importance of combining the ease of expression with the ease of interaction in the adaptation of enterprise software.

8.2 Introduction

The notion of enterprise software as an adaptive system that needs to evolve based on the challenges a company faces, and the active role end-users need to play in this situation, has been formulated very early on (an overview can be found in Davenport [43]): Today's systems usually follow the process-oriented perspective that has been established in the early 1990s following the success of Business Process Reengineering [123].

8.2.1 Business Process Modeling

A 'business process' is a logical set of activities leading to a special business purpose [193], in which they are represented with different notations. In the Business Process Modeling Notation (BPMN) several categories were introduced to simplify the language and to design models on different levels of complexity. Nevertheless, BPMN was developed for technical models of business processes [193] and does not include an end-user perspective. Another important approach, the Architecture of Integrated Information Systems (ARIS) [173], aims at enabling companies to model, analyze and optimize business processes. In the field of object-oriented software engineering, the Unified Modeling Language (UML) includes different diagram types, such as business modeling, object modeling and component modeling. All these notations seem to be quite complex. All of them have been created to support professional process and IT designers with modeling processes.

Computer systems support the process of modeling at different stages. Ellis et al. [52] underline the difference of the workflow model and the workflow system (execution module). While the model enables analysts and administrators to define activities and to assign them to different people, the workflow system consists of the execution environment and interface as seen by the end-users. Professional modeling tools such as the WebSphere Business Modeler, the Oracle BPEL Process Manager or the SAP NetWeaver Composition Environment are embedded in a more general business process solution with interfaces to other relevant software subsystems that support the analysis or the semi-automatic execution of pre-defined commands. Such tools are known for their high complexity, their broad range of functionalities and as such they require a rather extensive commitment to learning. For users with low technical expertise, modeling tools are difficult to use, even if supported by visual representations [144, 116]. The most common ones are based on the box-and-wire metaphor that presents sequences and logical connections through lines connecting decisions or domain concepts.

8.2.2 End-User Development

Software systems are used in different environments where the context differs from case to case. As needs and demands of users may change over time, the optimal functional range can never be completely estimated during the design process. Adaptations are necessary and become especially important at 'use-time' [57, 140]. Concepts of End-User Development (EUD) support such flexible adaptations by enabling end-users to adapt and reconfigure systems on their own [114]. Such software systems, which are e.g. based on a component-based architecture [198], are necessary in order to empower users in easily making their own adaptations. While EUD can be understood as an on-going process in relation to the work practice and collaborative use, Pipek Wulf [140] and Stevens et al. [184] refer to the concept of 'Infrastructuring': Such conceptual framing underlines the importance of a design-in-use that involves all stakeholders in designing working infrastructures over a longer period of time.

Several EUD techniques are available to support professional and less technically experienced users. As mentioned by MacLean et al. [160] in their Buttons concept, tailoring power depends on the skills that are required to be able to do the tailoring. A tailoring culture requires flexible systems that support all users in a gentle slope. The Buttons system also enables the sharing of individual improvements, which benefits the whole community. Such collaboration support is often stressed as being one of the main drivers of the EUD. The system developed by Kahler [152] for example, enables a structured exchange of modifications made in Word, by using public and private repositories. In order to design a gentle slope of complexity, several EUD techniques are available. Liebermann [158] introduced the programming by example paradigm, which enables the capturing of an often-used series of interactions and their (re-)use with different parameters as input. Concepts such as natural programming address users with little or no experience in using (traditional) formal programming languages. The natural language of the focused user group has been used as input for the computer systems to realize programming options [166]. Instead of using less complex commands, forms of visual programming can ease (re-)creation of virtual artifacts by using representatives that are oriented at the specific application domain [163]. The interface of such systems often is realized as a construction kit that makes the (re-)positioning and connection of components that represent different activities and data possible.

8.2.3 Process Modeling for the End-User

For end-users, changes beyond the idealized version of the preferred process are only very difficult to realize or not at all. This is problematic because business processes are not always static, nor are the work steps always the same. As already stated in Van der Aalst et al. [2], it is necessary to combine the very structured and process-centered workflow domain with more (unstructured) information-centered solutions. As an approach, van der Aalst introduces adaptive workflows as a system support that is able to deal with certain changes. Such changes include individual (ad-hoc) and structural (evolutionary) changes. In order to handle dynamic changes, van der Aalst et al. [2] presents a generic process model approach that describes a family of variants of the same workflow process.

Mendling et al. [122] point out that end-users receive less support in creating process models that can be easily analyzed and understood by business modeling experts. Based on previous experience, they present seven process-modeling guidelines that help experts simplify their model and therefore make them immediately usable and more comprehensible. The work of Agostini Michelis [4] focuses on flexible process changes for process instances by end-user themselves. In order to handle exceptions and breakdowns, the MILANO workflow system allows end-users to alter the workflow. The system supports such adaptations by enabling forward and backward jumps. Even if the end-user can change the flow of the work this way, a (well-proven) model does not need to be altered continuously.

Conceptual modeling becomes important in various areas of business life. As shown by Davies et al. [44], the use of ER diagrams is the most frequently used modeling technique in practice. One of the main reasons for modeling is the support of communication among stakeholders. As language and expertise may differ between the practices, the different stakeholders have to find ways to come to a shared understanding. As a solution, boundary objects can be used to support communication between members of different communities [6]. In order to interlink the end-user and designer/developer domain, participatory design oriented methods can also support the modeling process. Of special importance is the CARD technique (Collaborative Analysis of Requirements and Design) described by Tudor et al. [147]. Here, different cards can be (re-)arranged in collaborative sessions to (re-)design activity or task flows. The cards are (semi-)structured templates that describe an activity in more detail. Cards are usually taped on a large sheet of paper to serve as medium for other stakeholders who are also interested in the results.

Muller [124] extended the CARD approach so that it can now be used for more structured and layered participatory analyses. A similar approach is the collaborative users' task analysis (CUTA) as described by Lafreniere [155]. The color-coded cards depict activities, their duration and frequency, and are put in order on a table to create the correct schedule. Further concepts and modifications include Situation Cards [154], Inspiration Cards [79] and the Instant Card Technique [11]. All of these techniques try to build a bridge between modeling experts and end-users, by creating a conceptual model in the sense of a boundary object. However, even if such CARD-techniques have proved to be a valuable source in creating a shared understanding, and involving users in the design, there is still a gap between formalizing and (re-)using the output of such creative sessions.

8.2.4 Visual Metaphors to Support Process Modeling by End-Users

In order to support users in modeling, the choice of abstraction level is crucial [126]. Visual metaphors can support the appropriation of systems. Such a metaphor is related to a graphical representation with meanings similar to analogies, e.g. from the real world. As described by Hsu[97], visual metaphors stimulate the excitement and attention of the user. In order to support visual programming, Blackwell [21] recommended using implicit metaphors. One example is the use of the dataflow model, where data moves along wires [22]. Such representations strongly relate to the box-and-wire metaphor: Functionalities or modules are represented as boxes that are connected with lines, different kinds of boxes, lines and gateways can be used to represent different types of logic. Component-based software environments make use of such representations to create a new artifact by re-using exiting modules. In such an understanding, software packages are presented as components with well-defined interfaces that can be connected with each other, without considering the precise implementation [40].

Several tools are available that support modeling and modifying services via easy-to-use interfaces. Visual programming tools, as e.g. implemented in the FreEvolve platform [197], support the (re-)composition by choosing relevant elements and connecting them in a meaningful way. Web 2.0 based modeling tools such as Yahoo Pipes or MS Popfly enable the creation of process descriptions called mash-ups. By adding, combining or (re) adapting web-based services, functionalities that are more complex can be realized. Daniel et al. [42] point out that many approaches for web service orchestration help coordinate pieces of software, but hide the human aspect. Their systems allows composition of distributed UI's. Costabile et al. [39] present another approach that considers the needs of different user communities in the design process of interactive systems. The adaptation of complex software systems can also be increased by the use of "pragmatic adaptive user interfaces" [178]. Another example is ADIEU, developed by IBM [84], an assistant-based tool that creates service compositions and web-based interfaces. Another approach called Simple Service Orchestration (SISO) is realized as a graphical BPEL editor and supports modeling experts in creating new service compositions [101] more easily.

Modeling on the computer screen is the most common method. However, as already shown by Nardi [126], the limited space on the screen is a problem when it comes to visual modeling. Brainstorming sessions are also often interrupted by different actions within the physical space, e.g. by discussions, looking to each other vs. looking at the screen and using informal descriptions. In the last few years, different alternatives have been developed that make modeling more intuitive. Concepts that are based on haptic interactions have become especially important [105], systems focusing on a more natural interaction, e.g. by using pens, enable a stronger focus on the interaction rather than on formal aspects [187]. Different techniques can be used to realize sketch-based modeling tools. In previous work whiteboards, tablets or digital paper technologies were used. The SILK system [111] enables the fast creation of electronic interfaces, by recognizing interface elements drawn with a pen. 'Knight' [144] supports the collaborative modeling of UML diagrams by sketching on an electronic whiteboard. MaramaSketch [74] supports the recognition of different types of diagrams.

Pen and paper-based user interfaces bridge the gap between the virtual and physical world in order to make use of both [41]. The creation of models and designs is a creative process, very often done by first making sketches on paper [111]. Sketches of models can be created quickly and without much effort [125]. Instead of modeling in a rather formalized way, sketches on paper can easily be enriched with informal elements, such as comments or images. Un-experienced users usually contribute in this way rather than in reference to a computer-based model [195], and this collaborative work can be supported by using large sheets of paper [41]. Other advantages are the familiarity with the media, the common access from different viewpoints and options to annotate and enrich the project in a collaborative and creative manner. On the other hand, paper is a static medium that does not offer options for feedback and flexible re-creation of the content written on it.

8.2.5 Integrating the End-User: An Interactive Process

In order to empower end-users in adapting processes they are working with, our conceptual frame distinguishes between the complexity of the process, the complexity of the model and the complexity of the language. End-users with a profound understanding of the complexity of the processes (their current work), normally have not expertise as modeling-experts. While formal modeling requires a different kind of expertise (abstraction, using special tools, considering the complexity of related activities, etc.), we explore alternative directions to reduce the complexity for influencing processes. Easier options for end-users to reflect and express their work can be reached by reducing the complexity of the model. To support such user involvement, the complexity of the language needs to be adapted in a way that user can make sense of it. The interface to create and change the model (includes language entities and visual representations as well) needs to be easy to understand and intuitive to use. At the same time the language needs to be powerful enough to abstract with more formal elements. The resulting model does not need to be complete in a sense that it automatically can be transferred to a system for process support. But as shared reference it can be used by modeling-experts further on to integrate (sub-)models and support them by the system.

We have seen that the challenge of allowing end-users to understand, adapt and manipulate adaptive software systems has been addressed by developing simpler notations. These nevertheless still are not to easy to use, as a certain level of complexity is necessary to define the behavior of adaptive systems, and to support the interactions between actors, covering different aspects of the expertise necessary to implement and change adaptive software. Neither of these strategies has led to a complete success in integrating end-users, so we are specifically looking at the question of how users understand and perform visual modeling using the box-and-wire-metaphor (chapter 3), and how the interaction between end-users, more experienced users and modeling experts can be further simplified (chapter 4).

8.3 End-user process adaptations: Understanding and expressing

The aim of this study is to investigate how end-users articulate and reflect on business processes they are involved in. This work presents an empirical study that took place at an airport in Germany. We will present the adaptation practices in several departments that use a disposition system. To enable end-users to reflect on their processes and accomplish adaptations more easily, a business process modeling language is needed. Such notation should also allow end-users without professional IT training to model their processes and to change them accordingly. We conducted several explorative workshops with end-users and asked them to visualize business processes from their current work. Without pre-structuring the activities, e.g. as was done in the CARDS technique [?], we based our exploration on a plain box-and-wire metaphor. Based on an analysis of how users represented their processes, we deduced the requirements for an end-user friendly business process representation. Based on this, we present an intuitive notation, the End-User Process Language (EUPL), which was evaluated in the field. The aim of this language is not to enable end-users to model formal processes, but to articulate their view to the process modelers.

8.3.1 Empirical Study

In order to understand the organization and the practice of agents, we conducted an empirical study at a leading a leading international service provider for the aviation industry/airport business. The company is the operator and owner of a major airport in Germany. Furthermore, they offer services in different areas of airport management at other national and international airports. 'Ground handling services' is a strategic business unit and is an important revenue driver of this company. The company manages the handling of both people and luggage. They use a variety of software tools to monitor, plan, and schedule the processes that make an airport work. The systems handle some services autonomously and automatically, for other services they just deliver visualizations and notifications that allow the ground staff act accordingly. Nevertheless, the systems need to constantly be adapted as the organizational environment changes, e.g. due to new safety regulations, construction at the airport, or the changing needs of the airlines.

For our study, we focused on different actors, who deal with the software applications and their adaptations on different levels. Besides explicit requirements, we wanted to explore other implicit requirements, such as informal information about business processes. To understand the application field we used several methods: we conducted participatory observations, interviews and document analysis. In a first step, we evaluated the business analysis documents of the departments (more than 500 pages), system analysis documents, and decimations of the disposition systems and the handbooks of quality management. Furthermore, to understand current needs, we read the requirements of a new disposition system. It became clear that specific abbreviations like ATA, KSS, HOT, AVI or Off-Block-Time, Walk-Out Assistant or Ramp-Agent made it difficult to understand the entire context. Furthermore, we conducted participatory observations: Aside from unstructured participatory observations of about 45 days, we conducted structured observations of the operation management of the disposition system (three days). Additionally, we conducted six semi-structured interviews56 with administrators of different departments ranging from 27 to 92 minutes, with an average time of 60 minutes. The interviews were recorded and transcribed. Afterwards we analyzed the material with regards to the following questions: Who does the tailoring of the disposition system (role, education, IT expertise)? What are the reasons for tailoring? How is tailoring the disposition system done? What are the limits of tailoring? How relevant is the tailoring of business processes?

8.3.2 Tailoring in Practice

In the field, it is possible to distinguish between several different roles: drivers, who do operative work at the airport, like driving passengers from the airplane to the terminal, schedulers, who are responsible for the disposition of resources, such as the drivers and buses, and system supporters, who are responsible for the maintenance of the master data. After analyzing our data, we found several reasons for tailoring in the field. Some are based on new customer requirements, many are based on operational requirements, while others are based on new security regulations, easy adaptations that consider the master data of the system. Actors adapt data of cars, airplanes, airlines, airplane types and other resources. These adaptations were done by system support with the master data editor.

It is possible to distinguish between the adaptation of master data, rules and business processes. These categories differ in the power of their tailoring functionality and the tailoring expertise of the actor. MacLean et al.'s [160] model about the tailoring of workers, local developers and programmers, coincides with this observation. Our observed tailoring of master data, rules and processes can be transferred to this model (see figure 22). It shows that usually a lot of effort is needed if someone on the level of master data adaptations wants to do adaptations on the level of rules; their own staff usually does both kinds of tailoring. Adaptations on the level of processes are usually done with the help of a software development company. However, it also became obvious that the company would like to be able to do adaptations on the level of processes, thus making employees more flexible. An easy, user-friendly process-modeling notation is a precondition for easy process adaptation. This can be based on other descriptions, but it needs to be simple and easy to use for the target group of end-users, not just for developers. Therefore, the current practice and knowledge of those actors needs to be considered.

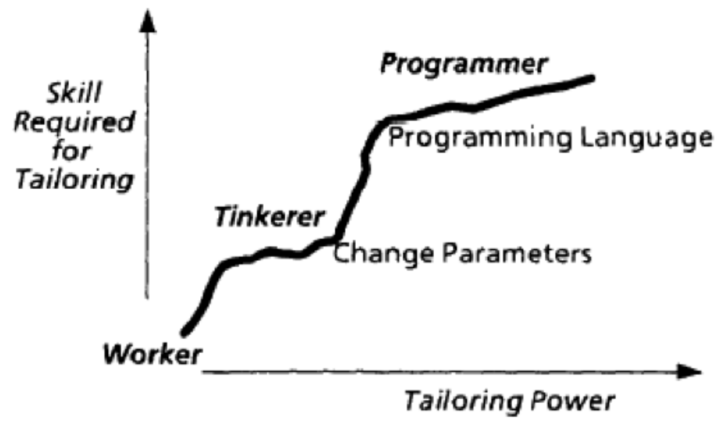

Figure 22: Adaptation of the disposition system on the different levels of the “Taylorability Mountain” (based on MacLean et al. 1990[160])

8.3.3 Modeling Workshop

In order to support employees with different roles and expertise in modeling, a description needs to be easy to understand and use. The language also needs to be powerful enough to enable system operators with different experiences to adapt and modify processes (compare figure 22). To develop the requirements for a process modeling language, we used participatory design workshops [109]. These workshops were conducted at the work places of the system support. We asked three different actors to model their business processes. Although all of them are system operators, they each had different experiences in modeling. One of them had already accomplished a course on modeling, while the other two were less experienced. First, the participants reflected on often-used transport services by drawing on paper with pencils in four different colors. In the second step, the same participants had to design more complex processes with the box-and-wire metaphor, so they could use materials from the first step and then edit cards of different colors (see figure 23). We introduced the cards and then gave some examples. We asked the participants to draw and explain what they were doing by thinking aloud. After finishing one task, the participants were interviewed with regards to the requirements for developing a very easy-to-use process language. Therefore, it was possible to add exceptions, special cases and coordination processes to their model. The duration of each workshop was in average about 2 hours.

Figure 23: Workshop with one system operator

8.3.4 Results from Modeling Workshop

The aim of the first step of the workshop (free modeling phase) was to understand how participants draw services. During the workshop, the airplane carrying process was modeled with participant A. In this process, the airplane is carried from one place to another at the airport before takeoff. Participant A was very inexperienced with process modeling and thought about it for quite a long time before he started to draw. He used boxes-and-wires: boxes for systems and then he added descriptions. Furthermore, he modeled only the standard process; he only added exceptions after he was asked to (see figure 8.3.4, left, red circle). Participant B modeled an inbound bus transport process. This process coordinates the transport of passengers from the field to the terminal. Since he was already a bit experienced in modeling, he used boxes-and-wires in an efficient manner, and used different colors for different aspects. He first thought of how to draw the process and what he wanted to focus on, and then designed a good process model. The colors symbolized operative processes (blue), the confirmation status of the driver (green), the demanded new status (red) and the exceptions (black). Participant C modeled an inbound luggage transportation process, it contained the transport of luggage from the field to the terminal. The process was based on a storyboard and he did not use boxes and wires explicitly. He had drawn on a blackboard as done in school: The different aspects were explained in a structured way on the sheet, the result was not a process model, but a description of the process, and the different steps involved.

In the second phase of the workshops, we wanted to test the use of boxes-and-wires more explicitly. The participants were asked to use pre-defined cards to draw the processes. Participant A had to design the push-out-process, a process that describes the steps involved when an airplane has to be towed to position to be able to start. Contrary to the first task, the participant understood the aim of the second phase very quickly. To help him understand the process of modeling, some cards had already been prepared and covered existing events. After the participant was asked, he also added exceptions. The task of participant B was to design a ramp-direct-service, that brings passengers from one airplane to another, in case there is little time between flights; this process is used when a plane is late and the airport management wants to avoid passengers missing their connecting flight. The participant did not use the pre-designed cards, but designed his own cards. He used differently colored cards for different purposes. Participant C had to model a direct transfer process, which is when luggage has to be transferred from one plane to the other when passengers change planes. The

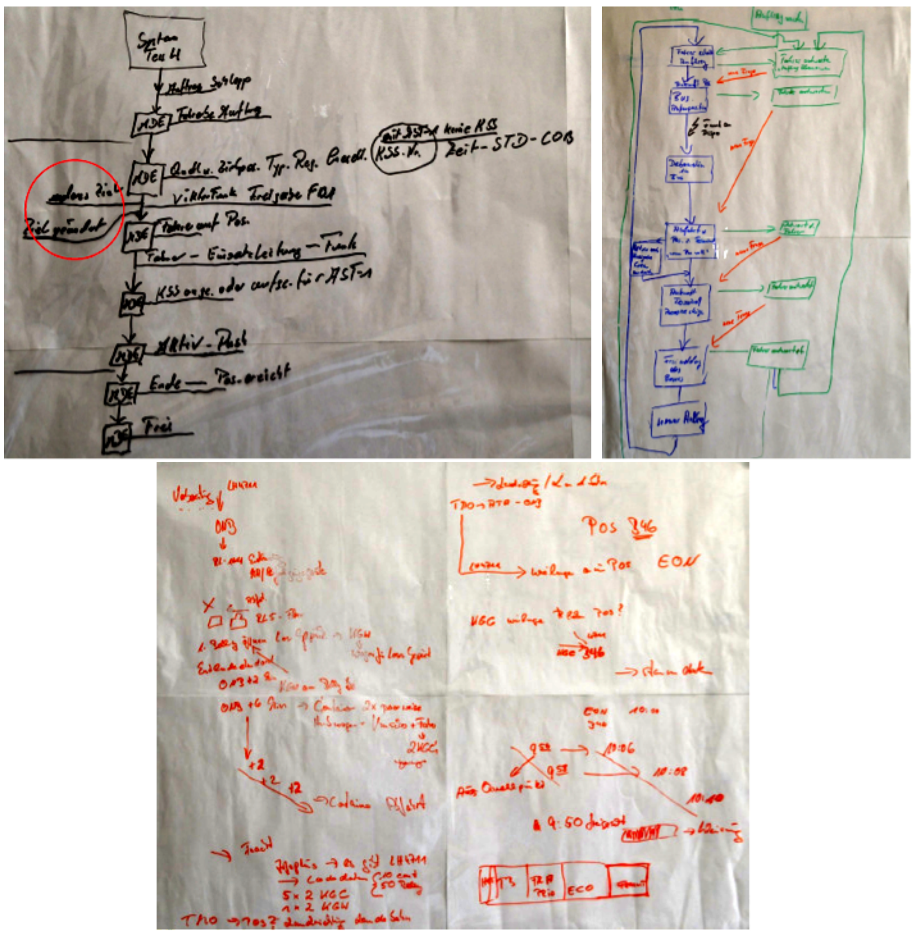

Figure 24: Overview about the free modeling of the airplane transportation process of participant A, the inbound bus transport process of participant B, the inbound luggage transportation process of participant C

participant used the cards, but did not draw connections between them. He arranged them in a line and the activities were drawn on the paper.

In general, the participants used the cards for events and activities very well. After we introduced boxes-and-wires, the quality of the results of the process modeling increased and became more structured and clear (especially for participants A and C, see figure 23). The box-and-wire metaphor is easier to use with pre-defined cards and should be a basis for a process modeling language. The box-and-wire metaphor seemed to be easy to handle for our participants, especially when we asked the participants to do changes in the process.

8.3.5 Implications for the Design of a Common Process Representation

Based on the results of the workshops, we identified several elements that needed to be supported in an end-user process language. Business processes are understood as a sequence of steps, the models contain activities (process steps) and events (their trigger or the results). Therefore, these categories need to be supported. A special event is a gateway to other processes. Lines were used to draw connections between boxes. In addition, alternative and parallel processes were also used. Comments contained other information relevant for the process.

None of the participants used Swimlanes, like in BPMN, which differ in the responsibilities of different actors, departments and organizations. Also, the junction and disjunction of processes like in UML, were not presented explicitly. Furthermore XOR and OR, like in ARIS, were not used. Although many of these constructs may be necessary to maintain the logical completeness of a formal language, or to keep an overview in complex models for professional modelers, they may not be necessary to describe the needs of end-users, and sometimes that may even be confusing. Based on our findings we recommend that different aspects should be considered when developing a process language.

R1: Box-and-Wire-Metaphor: The box-and-wire metaphor is an intuitive foundation for a notation that enables system operators to reflect and model processes on their own. Even though two of the three participants used this kind of modeling without any input from us, the results were clearer in the second step when we asked the participants to use them. Also other business process languages like ARIS or BPMN use this metaphor, but with different boxes and lines. An end-user language should reduce this to the required minimum.

R2: Focus on the work practice of the user: If end-users model business processes, they mainly focus on their own work practice and model processes in which they are involved. Therefore, this process might only represents one part of the overall process and is only easy to understand for the participant herself or himself. If an overall process has to be modeled, more participants could design the process cooperatively and thus create a more objective representation. We also observed this in our workshop: in the RDS process both participants used gateways to other processes. If those processes are combined, an overall process can be displayed.

R3: Events as the center of the process: One question in the analysis of the workshop was what the center of the language could be. Based on the workshop, we think that events are the center, because those were used in every case. Between those events, activities can be added to enrich the process and to focus on specific details.

R4: Slim processes: Another very important demand of the process representation is the facility to understand the process easily. This concludes in a reduced amount of process elements to be easy to understand. Furthermore, this leads towards comments to explain difficult aspects of a process. Furthermore, a fixed direction of the process and not many exceptions make it easier to understand. If a process is too complex, a separation into several sub processes is necessary.

R5: Focus on standard processes: If end-users model processes, they should focus on the standard process. Operative business processes in the field of our study usually follow a fixed model. We found that the participants understood the process better when it followed a fixed procedure. End-users should not try to add all possible and improbable exceptions, which would make the process less easy and clear. These users are not very experienced in business process models, and therefore these exceptions would make the whole process much harder to understand for them.

R6: Design from the top to the bottom: Another question was what direction a process should follow. All processes were modeled from the top to the bottom of the paper. Process steps that followed another one, were drawn underneath the first step. It was only when the paper was full that the participants started with a new column. Alternative events were drawn horizontally.

R7: Predefined Events and Activities: In the second step of the workshops especially participant A, who had no experience with process modeling, used pre-defined events and activities. This enabled him to use the language in a proper way. He realized the meaning of the elements – especially recurring events, and used them. A provision of probable elements can help end-users to start modeling. This is especially important from the software adaptation perspective when existing elements have to be included into other processes.

R8: Comments: An easy process model, based on box-and-wires, cannot contain all important aspects that describe a process. Further, important aspects of the "context" can be added as comments. They can contain everything a user cannot explain with the existing elements, e.g. information about regulatory environments, examples, informal exceptions or special cases.

The derived requirements lead toward an end-user process language (EUPL). This language could empower the user to draw, change and explain their processes. The focus of this language is not on formalizing the processes in a very detailed way, but to describe the process in a language familiar to the user.

The language itself consists of four different symbols. The centers are events, which are drawn as blue boxes. The events are connected with arrows. Events can be marked with an "S", representing a gateway. This enables one to distinguish between different responsibilities. Other boxes represent activities. They are represented, as a green box with a double line on the side (see figure 25). They are not obligatory, but can be added between two events. It is also possible to add more than one activity between two events. This language has no specific rules, like in ARIS, where after each event an activity has to follow. In our language, events are the center and can be added with other elements. Furthermore, annotations are possible, which can combine further descriptions or required resources, actors, systems or requirements. If after one event two arrows and two events follow, this represents alternative or parallel processes. When using this language in software applications, the software should ask the user if they are parallel or alternative. We chose not to distinguish between alternative and parallel processes, because the aim was to design the language as easy as possible and not with the aim of focusing on a technical interpretation of the created processes, but to explain them to process designers, who use them to create processes in required tools.

8.3.6 Evaluation of a Common Process Representation

To evaluate the end-user process language we designed the process models of the workshop participants in EUPL and gave these representations to them. Based on this, we did three interviews that lasted in average of 16 minutes with each participant. All participants recognized their processes and un-

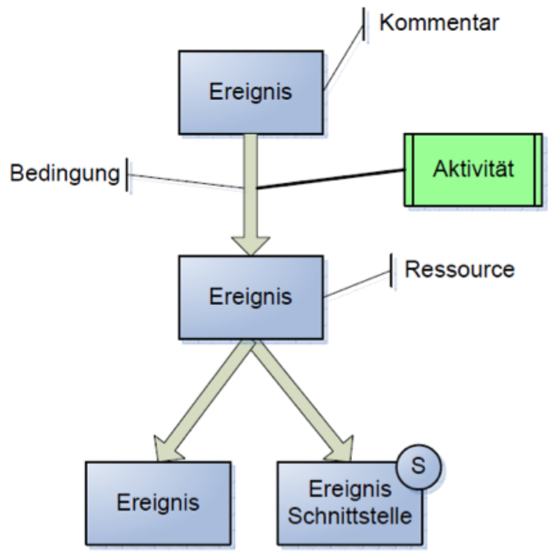

Figure 25: Elements of EUPL

derstood the symbols. One part of the process model was a brief description of the different symbols. Participant B said that the meaning of the symbols was also easy to understand without the descriptions. Participant C mentioned, that different colors for activities and events were very important. Participant B said that a differentiation of elements was good, but further differentiations would be "very circumstantial" and would result in a situation where "nobody knew what is meant with a symbol". Participant A also said that more differentiation would increase circumstantial representations. All participants agreed that they could express all necessary elements related to their business processes, and that EUPL contained all important elements. Participant B proposed that all activities could have a comment showing who is doing this activity. The other two participants wanted to use this only in special cases. Participant B also proposed adding numbers to all elements, to be able to refer to them in comments. All participants agreed that events were the center of an operative business process language. All participants also recognized the alternatives in the model. Participant C said, he would just model the standard process,"'which takes place in 95% of all cases"' to improve the clarity. To express alternatives, participant B criticized constructs as XOR, like in ARIS, because those would always be difficult to understand.

All participants thought, other co-workers would understand these processes. All of them gave positive feedback and mentioned that the symbols were easy to understand and the overall usability of the language was good. In general, we think that a representation like this can help bring business and IT closer together by providing an easy to use language based on boxes-and-wires. Participants were able to understand the process and judged the power of the language to be big enough for their processes.

8.4 End-User Process Adaptation: Interaction Issues

As shown in the previous chapter, an easy to use representation can support end-users in the modeling of their work processes. An easy to understand notation, as presented in the form of EUPL in the chapter before, is a step towards a more intuitive process handling. As another step we focused on new interactive concepts for modeling that also support the collaborative and creative character of a group work. While modeling with paper and pen seems to be a natural way of creating a representation with formal and informal elements, we were interested in how a computer-based adaptive system can support the process. In the following chapter we will present the results of a collaborative process modeling session with paper and pen, describe the developed adaptive system and draw implications by presenting results of a small explorative evaluation.

8.4.1 An Experiment in Pen-based Modeling Practice

In order to understand the practice of pen and paper based processes modeling, we conducted a pre-study with three users, who only had little experience or no experience at all in modeling. Participants should collaboratively sketch business processes on paper already known to them. In some aspects, this study has similarities with the study described in the previous chapter. However, compared to the first case where each of the participants sketched models by her- or himself, here the participants all sketched a model at the same time. Three people from a small and medium sized company (SME) with around 150 employees attended this pre-study. None of them had formal expertise in modeling business processes, but as key users of SAP they all had solid knowledge of customizing internal SAP software systems (see Table 1). Six people, involved in the research project, also attended the workshop in order to structure and guide the meeting, conduct interviews and make field-notes/images. The five-hour workshop took place at the university and was divided into two parts: an introduction and a design phase. The basis for the modeling process was a large writing pad with paper sheets the size of 1x1.40m (see figure 26). Additionally, different kinds of office supplies were available for the modeling session, including paper sheets in several sizes, post-its, colored pencils and a board.

Participant	**Role**	**Modeling Experience**
P1 (male)	Leader of the IT-department	SAP key user, already modeled in Microsoft Visio
P2 (female)	Assistant of the executive board	SAP key user, no advanced modeling expertise
P3 (female)	Purchasing manager	SAP key user, no advanced modeling expertise

Table 2: Participants of the modeling workshop

In the introduction phase, several business scenarios from the work domain of the participants, were discussed and specified. Afterwards, one of the scenarios was chosen for collaborative pen-based sketching. The chosen scenario was related to the planning of order processes. In order to get an overview of all the product groups, a complex list is necessary, which includes stock, change of stock, planned selling and current selling. The relevant data can be found in different ERP modules and needs to be combined in a structured Excel list. Within that list, additional calculations are necessary.

Before the start of the design phase, we introduced the box-and-wire model. On a large sheet of paper (1x1.40 meter) several actions were possible. Pre-prepared boxes cut out off paper, with an input and output port drawn on it, were used as empty entities for events and activities. It was possible to position these entities on the larger paper sheet and connect them by drawing lines between them. Additionally, annotations were possible by using pens with different colors.

At the beginning of the design phase, participants started to discuss the aim of the chosen business scenario as well as implications for modeling. As a first step, a table with columns was drawn on the paper that represented the SAP modules, where the relevant data could be found. In the following discussion, the participants started to think about how to represent the scenario on a box-and-wire level. They decided to use a separate box for

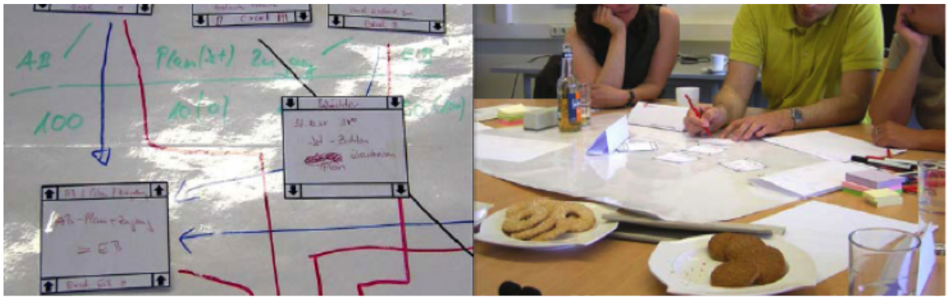

Figure 26: boxes and wires (left) and design workshop

each module involved. A summary of the sketched model is shown in figure 27. The input port of the box was annotated with keywords relating to the needed data, e.g. from SAP modules. Additionally, the participants mentioned 'experience' as a further source of information. With this annotation, the participants underlined the fact that experience was necessary in order to calculate the correct planning. In this specific case, the planning process also included trend predictions and estimations from the marketing department on new trend colors. Such experience was mentioned as a human factor that cannot be automated. The output ports of the boxes were annotated with the target format (mostly Excel). Further search, selection and transformation criteria were written in the middle of the box. Participants also sketched event-driven connections between the boxes, as e.g. indicated by the grey connection line in figure 27. This connector was labeled as the 'watcher' – a process that supports the automatic updating of data at the end of each month. Together with the output of other boxes the input for the central calculation box was directed to a final box that represented the combination of all relevant data within an Excel list. The numbers drawn on the lines going to the final box, represent the ordering of the resulting columns within the list.

As shown in the previous chapter, the workshop provided insights into how end-users without special knowledge in modeling, represent and reflect relevant business scenarios in an explorative way. By using a pen- and paper-based environment, the participants were able to 'model' in an informal, collaborative and creative manner. Beside the formal elements provided (empty paper boxes), annotations (e.g. for the ordering of the columns) and informal extensions (e.g. by using 'experience' as input) of the process model were used to create the process representation. The workshop also showed that the prepared boxes were used for different things, e.g. for calculation,

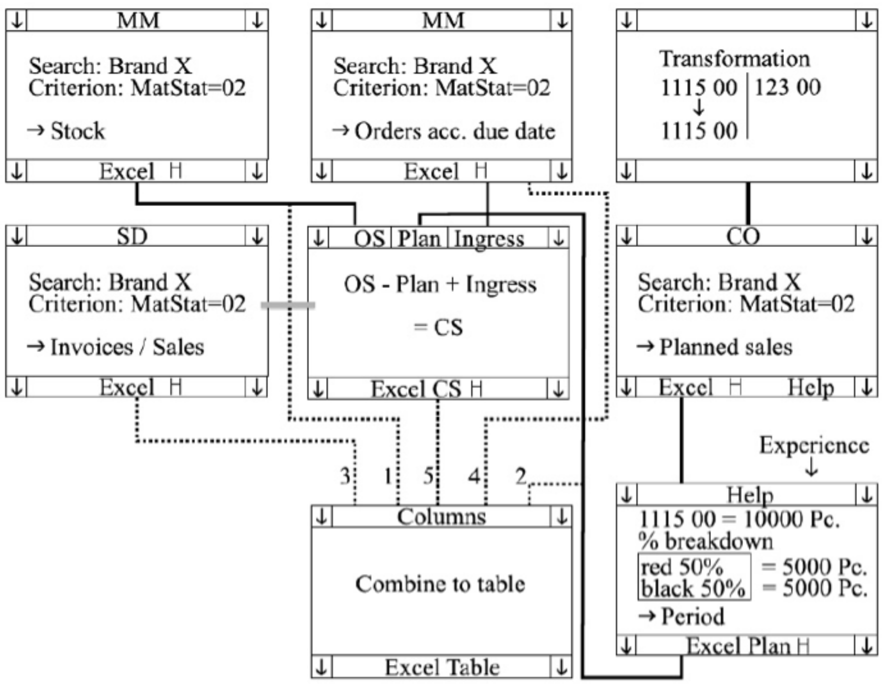

Figure 27: representation of the sketched model

conditions and data sources. The method to model this way, was easy to understand, and the box-and-wire metaphor supported the process quite well.

8.4.2 Articulation Support for Conceptual Modeling

From the experience gathered in pre-studies, several lessons were learned. It has clearly been shown that paper-based modeling can be used as an easy-to-use and intuitive method, to let end-users express activities they are involved in. End-users – also with no or little experience in modeling – can articulate their work (and process steps) quite easily by sketching on paper and using the box-and-wire metaphor. Many advantages of such a form of modeling became obvious, so questions arose of how these paper-based modeling activities can be integrated in an IT-supported socio-technical modeling practice, where different stakeholders are involved. The focus system should support users in the collaborative creation of a model, in the transformation into a digital representation, with the extensibility and convertibility of the model, the computer generated feedback and guidance. The sketched model (the paper-based one as well as the digital representation) can be used as a boundary object that mediates between members of different Communities of Practices (CoP) – especially between end-users and modeling experts. An ideal process flow includes three parts:

Step 1: End-users can reflect upon their work practice in collaborative modeling workshops. Processes are sketched on interactive paper that allows the automatic transformation into a digital (not necessarily formal) representation. Users from different CoP and with different roles can also attend, in order to understand and/or guide the scenarios. Step 2: The digital representation can be exported into different formats, so that modeling experts can continue working with the material, e.g. transform it to an executable workflow model. Formal parts of the sketch as events and activities will be automatically transferred to the relating formal elements, so that modelers can check and correct them if necessary. In addition, informal elements will be recognized in order to provide meaning and remarks that are understandable to different stakeholders. Step 3: The existing representations of the process (paper-based as well as the digital one) can be further used as a boundary object that bridges the end-user and the developer domain. The representation can be connected to the formal model in order to empower end-users, enabling them to inform other stakeholders about changes.

8.4.3 Supporting Modeling Interactions with a Paper-based Approach

As a first answer to dealing with pen-based input and transferring it to a digital representation, we would like to present an adaptive system that supports collaborative modeling. As a basic technology, we decided to use the digital pen technology from Anoto (www.anoto.com). Small cameras at the tip of the pen capture the input written on paper with a very fine dot pattern printed on it (the paper looks a bit greyish because of the pattern). The dot pattern makes every location (and every pen mark) on every sheet of paper recognizable. The captured data can then be batched or streamed to a computer via Bluetooth. By choosing this technology, every user can be part of a collaborative modeling session with his or her own pen. Just as with a standard pen, modeling can take place by sketching on paper. Several frameworks are available that support the creation of paper-based functionalities. In our case we chose the Paper Toolkit [201], as an open source framework with high level API that already includes basic functionalities to support several pens, related events and interaction modes. To recognize gestures we chose the $1 Recognizer [196], which allows for fast recognition without training. The recognition of text was handled by a Tablet PC Recognizer Pack [8], which is included in the Microsoft Tablet PC Platform SDK [9]. For the auditory feedback the Microsoft Speech API [10] was also used.

The architecture of the whole system is shown in figure 28. Input from the digital pen will be transferred to the Pen Server, which handles low-level communication via pen and PC and then calculates the current position. The Pen Server can handle and identify several pens. The stored data is then transferred to the Ink Manager, which is responsible for the high-level calculation of the pen input. The active context is calculated based on the type of paper (analyzed by the Paper Manager) used, the kind of current modeled element (analyzed by the Recognition Engine), the relating pen and the current pen state. The result of that calculation is directed to the Process Manager, which inserts the element into a digital process model. In order to connect the virtual model with the physical region on the paper, results are then remapped to the Paper Manager. At the end of the calculation process, the Feedback Manager is triggered to activate an auditory or visual feedback. The global file handling of load, save and export is done by the

[8] http://www.microsoft.com/austria/windowsxp/tabletpc/muiprodguide.mspx

[9] http://msdn.microsoft.com/en-us/library/ms840465.aspx

[10] http://www.microsoft.com/speech/speech2007/speechdevarticle.mspx

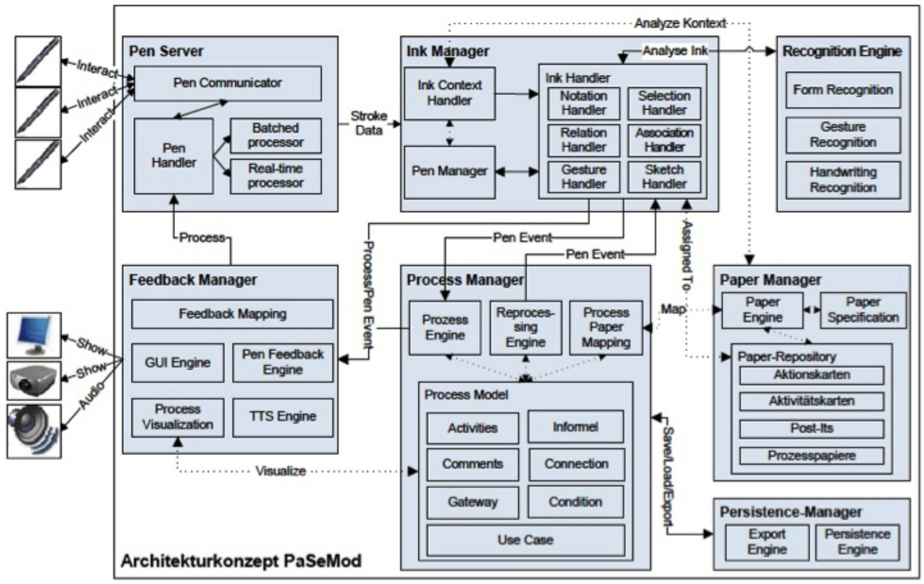

Figure 28: Architecture of the pen and paper-based recognition system

Persistence-Manager.

In order to support the creation of models in a flexible and dynamic form, the concept uses different types of paper (see figure 29). A 'process paper' is used as background for the modeling activities (1). The size of that paper can vary and be extended beyond any screen size. Events (red) and comments (blue) are represented with post-its (4). These post-its can be positioned freely on the process paper. Drawing lines between the stickers will represent the process flow from one event to others. Events and comments can also be drawn directly on the paper by choosing the correlating process mode on the 'action card' (3). However, in those cases the event cannot be replaced. Every event can be further described with a 'description of event' (2). Such a description is realized as a pre-structured questionnaire, where further details, including name, event description, function, input and output-data, can be specified. Additionally, the already mentioned 'action card' (3) provides an overview over all available process notations and pen commands. The usage of different sizes of process-paper and the simultaneous use of different pens at the same time, enable spatial arrangements in a flexible manner, e.g. in collaborative workshop settings with many end-users.

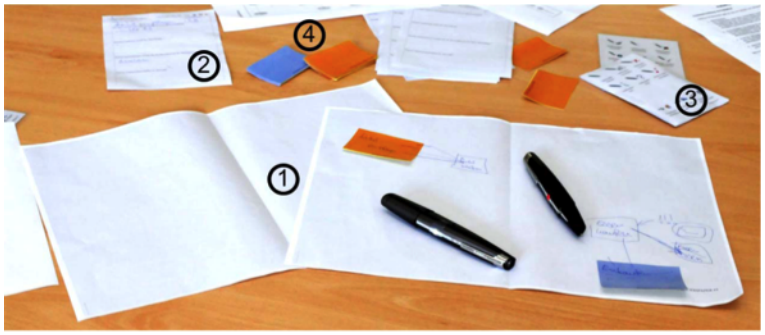

Figure 29: elements of digital pen and paper-based interfaces

8.4.4 Usage of the System

One advantage of the system is the synchronous (semi-)automatic creation of a digital representation of the sketched model. In order to bridge the physical and digital domain, several design decisions had to be made for the feedback mechanism. As the digital pen does not provide sufficient feedback, a combination of visual and auditory feedback on a computer was chosen. Audio output indicates an error in the automatic recognition of the modeling process. Feedback that is more detailed is realized through feedback dialogues that are shown in the corner of the digital representation screen (as shown in figure 30). The pens are marked with a color that is related to the feedback dialogues on the screen. By using this color code, the current state of each pen can be displayed.

The whole model is then transferred synchronously to a digital representation as shown in figure 31. Events, comments and annotations are represented in different colors to ease readability and to indicate if an element was recognized correctly. Even if linked to an event, the related description of the activity will not be displayed. Every modification of the physical model needs to be explicitly defined by using different states of the pen interaction. Removing an element requires choosing the 'delete' mode on the action card and to strike it out. Afterwards, the element or the link (line) can be replaced (when a post-it was used) or re-drawn.

In order to support the exchange with other end-users and with modeling experts, the digital representation of the sketched model can be exported in different formats. In the easiest form, the model can be saved as an image. Such a form of representation is easy to access by others who are interested in the domain. The model can also be used as a foundation that can be further adapted to include more complex options and integrate them into

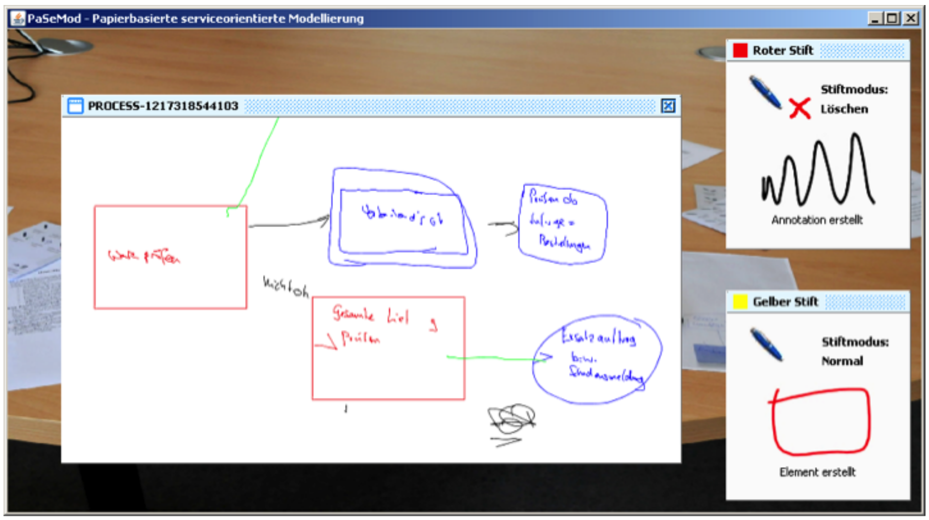

Figure 30: GUI with visualization of recognized elements and feedback boxes

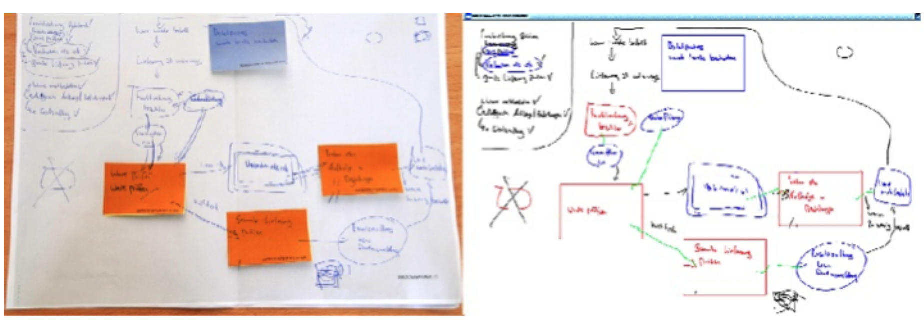

Figure 31: same representation in the physical (left) and digital world after recognition (right)

an existing IT support. The representation can also be converted into an XML file with a defined document type definition (DTD). As another option, the model can be exported to Marama in order to enable a clear separation of formal and informal elements. By using the Marama sketching toolkit [75], the sketch can be transformed into different parts of formal elements. This way the model can be optimized and be used as an input for modeling experts who work with professional modeling tools (compare also chapter 4.2 step 2).

The introduced system supports end-user and modeling experts in different ways. As already described in the introduction, a user may indicate changes to a given business process, e.g. as a result of an improved practice established over time. End-users mainly involved in those (sub-)tasks can meet with experts in a collaborative brainstorming session. The paper-based sketch is automatically transferred into a digital representation with formal and informal elements. Based on the representation, modeling experts can transform user-needs into a formal structure. Later, the end-user can indicate demands and needs for changes based on the sketch, e.g. in a collaborative manner, or based on the electronic representation, e.g. to highlight context-specific requirements. Concerning the importance, quality and quantity of such requests, modeling experts and decision makers can decide to adapt the model in order to synchronize it with the (best) practice. There may be different reasons for working with a shared reference, including process documentation, end-user training or quality management.

In order to adapt systems, the paper-based, as well as the digital representation, can be modified. For collaborative modifications, paper-sheets from previous brainstorming meetings can be used to remove entities or include new ones. The input is then captured and the digital representation, with the recognized formal and informal elements, will be updated as well. Changes can also be indicated individually, by changing the digital representation directly. For further work interesting functionalities may include marker for recommendation, adaptation and suggestions. The (semi-)formal digital representation can be used as input for modeling experts to transfer end-user indicated changes to the model which is executed by the system.

8.4.5 Evaluating Paper-based Modeling Interaction

The computer supported pen-based modeling and interaction concept was evaluated in an expert walkthrough before testing it with users. In order to track down critical incidents, several scenarios were tested. Based on these results the prototype was further improved, e.g. by using a bigger font for the digital text or by providing more stable action cards made of heavier paper. After that, the system was evaluated in a two-hour workshop with two users, who had already participated in the pre-study. Both participants (P1 and P3, see also Table 1) worked in small and medium sized enterprise (SME). One of them was the manager of the IT department and already had some knowledge in modeling processes with Microsoft Visio, while the other was manager of purchase with no advanced experience in modeling on a PC. Before the evaluation started, the system was introduced to the participants. While playing around with the system, the basic functionalities, the process elements and pen states, were explained. The usage test was done in the form of a walkthrough based on a collaborative scenario, where the participants were asked to articulate their thoughts (thinking aloud). After this test, separate semi-structured interviews took place with a focus on personal opinions, satisfaction and usability. In order to analyze the study later, the evaluation was recorded on video (user test) and audio (interviews).

For the scenario-based walkthrough, participants had to model a process from their own working context in a collaborative manner using the system. In order to reflect and model freely and ad-hoc, the chosen scenario was related to a process from their everyday tasks. The scenario chosen included the creation of a new article in the set, which required several sub-processes, including an analysis of sales options, the creation of the article and relevant views in SAP, planning the amount of sales, the triggering of ordering processes, and a quality check and payment. While focusing on the modeling of sub-parts of the entire process, participants were asked to express their thoughts, in order to understand issues and mental reflections. During the modeling phase, the participants were seated around a large, round table with access to the pen- and paper-based material described in the previous chapter. The pens were connected to a laptop, that also provided the audio feedback. The graphical interface of the resulting representation was projected on the opposite wall via a projector.

Participants only had few problems in modeling the process with the system introduced. The syntax and the meanings of the different process elements were easy to understand and therefore intuitive to use. As shown in figure 32 both modes of drawing (with and without post-its) were understood and applied. However, some problems occurred, when post-its were repositioned. It was considered to be less intuitive when the connection from the post-it to the process-paper in the background had to be removed by choosing the correlating pen mode and then crossing the small connection line. The participants expected a mode to misalign elements, so that the post-it, with the correlating content, could be easily repositioned afterwards.

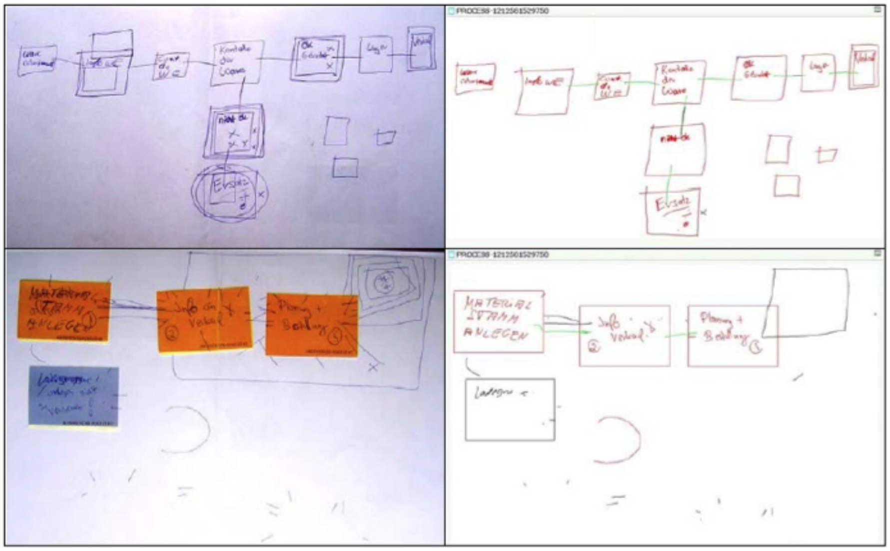

Figure 32: sketched models in evaluation (left) and recognized digital representation

The good usability of the system overall, was confirmed through positive feedback from the participants. "... It is only the question of dealing with the system and practicing and then, when you know how it works, it becomes your second nature." In the beginning of the evaluation, participants had some problems trying to get up to date on the current status of the pen. Even if the status of each pen was displayed on the screen, participants did not focus on it. "For me it was clear [that there were different statuses of the pen], but I did not pay attention to them at first, even though you can see the status in the top right window". More direct feedback mechanisms, such as LEDs positioned on the pen to indicate its status, may ease the usability here. The audio feedback can support the process, if one is modeling alone; in collaborative sessions, it is more irritating, as mentioned by one participant. However, the idea of triggering a different status of the pen by choosing a symbol on the action card, and to then use the pen in different modes, was easy to understand and therefore appreciated by the participants as a "good solution" "that is easy".

As one of the main issues, the realization of the feedback has to be considered problematic. While the audio feedback was more irritating than helpful in the collaborative session, the participants focused their work on the visual feedback provided on the wall via the projector. The participants constantly checked the current status of the pen on the virtual image, which in the on-going session led to a stronger focus on the virtual representation, instead of simply brainstorming on paper. It is also important to note that participants only used formal elements (see figure 32) and avoided making comments as done in the pre-study. One of the users mentioned as a reason, that he tried to make a "clear" digital process model without informal elements, but that this might change depending on the task. The informal brainstorming character of the workshop was lost a bit, as the technological setting suggested a less playful modeling behavior to the participants. The results visible on the paper were also constantly checked on the wall as well. A deduction for further improvements refers to the organizational schedule of the workshop: it seems to be valuable to separate the brainstorming phase on paper (sketching) from the direction/correction phase of the recognized model (checking). Technically, our system would have also supported this type of collaboration. One of the participants could shift the elements sketched on the paper to the digital form, e.g. by typing on activities or comments with the correlating pen status.

8.5 Integrating the End-User: Combining Ease of Expression with Ease of Interaction

Systems for process modeling, as they can be found in many adaptive enterprise software tools, need to provide appropriate interactions to be able to remodel the processes for which they provide services. Software tools that support modeling are normally mainly designed for expert use. The concepts of EUD enable end-users to adapt and reconfigure systems on their own [114], but the tailoring power depends on the skills that are required for the tailoring [160] itself and most notations have also been created to support modeling-experts [193, 173, 52]. A broad functional range that operates on complex notations enables the creation of fine-granulated formal models that guide the workflow. However, the models, normally designed by modeling experts, need to be (re-)adapted over time. Especially for knowledge work, such concepts need to be (re-)configured frequently, as processes are less structured and routinized. When a process is already modeled in a formal representation, end-users normally have no or little influence in the adaptation of that processes. Although employees may be able to articulate and describe best the process context that helps adaptive enterprise systems to deliver their services, they may not be able to model it in a formal sense. Employees can contact the modeling expert and ask for changes, but important informal aspects, e.g. that are related to the personal experience or that were identified in collaborative work practices, are not considered or can be misunderstood due to (re-)interpretation by others, and the remodeling cycles may take more time than is available. User modeling in human computer interaction [59] tries to address this issue.

The big challenge we want to overcome with our research, is how to integrate all experts necessary to adapt enterprise software (end-users as domain experts, expert modelers and mediating actors), so that their expertise can be articulated in a sustainable way. Many of the approaches we mentioned in section 2 worked out well with actors on the more professional end. With our concepts and studies, we aim to improve the understanding and the options for actors at the other end of the scale. EUD techniques, such as programming by example [158] or natural programming [166] provide less complex commands. Visual programming adds virtual artifacts oriented at the application domain [163]. In our studies, we looked at the intuitiveness and appropriateness of the box-and-wire-metaphor that is considered as the basis for most visual modeling languages (section 3), and we looked for different interaction modes with regard to a simpler, more collaborative modeling (section 4). In two studies, employees with less experience in modeling were asked to reflect on their work practice by sketching processes and using graphical representations. As shown in both pre-studies, the pen-and paper based interaction proved to be a successful way of sketching models in a more intuitive and creative way. Participants with less technical expertise in modeling were able to reflect on their work routines in a structured manner. The box-and-wire-metaphor was confirmed as adequate, but for process modeling languages it may be helpful to provide room for structured informal model content as well, which may not be on the same level of abstraction, and may even be describing a very local use practice. Comments could be made about process executions that are just relevant for one department and not for the organization as a whole. Again, this may not help the configuration of the adaptive system directly, but it may add to a user's understanding of its inner workings or to its being embedded in the user's practice.

Supporting use and configuration of enterprise software tools by appropriation support functionality (supporting collaborative appropriation [137]) and appropriation infrastructures (means to also connect the designers [184]), can improve technology-related interactions among users as well as between users and designers. This work has demonstrated that this interaction can be the key factor in achieving both: correct configuration of software tools and also working configurations, as well as the tight-knitted integration of the changing needs of end-users into the software maintenance loop. In this contribution, we wanted to address more fundamental issues in end-user driven adaptation of process-centered enterprise infrastructures, as current tools for process modeling only provide weak support of a direct involvement of end-users [122].

In order to integrate end-users, it is necessary to follow a dual strategy that combines "ease of expression" (using visual languages that allow end-users to express and describe the process context an adaptive system has to function in) with "ease of interaction" (providing interaction concepts that allow end-users to become creative in modeling work). An adaptive system should not only provide means to model its context or behavior, but also support the interactions that need to happen between end-users and expert modelers in order to cope with continuous changing needs in enterprise software systems. The ways of expressing processes has also become important to the point, where such representations can be (re-)used to guide others, or to provide the best practice [44] solution. Articulation support for end-users should consider formal and informal descriptions and representations for sub-areas of work practice, e.g. in supporting local groups of knowledge workers or providing the best practice examples.

Taking the findings from previous works and our pre-studies as an implication for design, we encountered the question of how a computer-based system can support such collaborative interaction by (semi-) automatically capturing and transferring it to a virtual representation as a foundation for further optimization, e.g. by directing it to experts, sharing it with others, modifying or recreating it. As a first step towards an easy solution for end-users, we presented a digital modeling tool that bridges the physical and digital domain by transferring and linking paper-based results from collaborative brainstorming sessions to a semi-structured, formalized digital output. Our prototype is able to recognize formal and informal elements written on paper and to transfer them to a digital model that can be forwarded to formal process modeling tools and be re-used later on. It is important though, to recognize that process representations do not provide the only computational basis for the services the system provides. They also become a boundary object for reflecting on activities at work, and a medium for conserving experiences. End-users can use the paper-based model as a means for mediating the communication with the modeling experts that support the adaptation in an e.g. more global framework. As an artifact, they make the complex work organization of an enterprise tangible, and the creativity that is invested during its creation forms a solid basis for the acknowledgement and the acceptance of the adaptive services. They may also foster the identification with the organization and its work practice as a whole.

The haptic interaction in the paper-based setting had particular advantages over screen-based, and even touchscreen-based, interaction. It resembled other types of creative work in enterprises that virtually all users were familiar with. The haptic qualities also added to an atmosphere of creativity that cannot be established on a ordinary computer screen, and even with large touchscreen displays the immediacy of touching and moving the material would be missing – these all are important aspects to win end-users with low familiarity of interactive technologies. The paper-based process model is also almost indefinitely extensible, as more paper can be glued and connected to the model, visibility issues due to screen size do not apply, and screen input control and turn taking is not an issue when working collaboratively with paper. The introduced system supports collaborative modeling by adapting changes synchronously in the digital visual representation. Thereby the representation looks exactly like the physical model on paper; the characteristics and creative character of the sketched output remains. By using the (re-)post-it mechanism the digital model of an already sketched process can be (re-)configured in the original physical process. Based on the tool, further interesting developments are possible. Physical paper-based elements could trigger commands for executions, e.g. a notification for modeling experts if the paper-based model was modified to articulate changes.

To better connect our approach with the work processes of expert modelers, modeling tools need to make transparent, how informal descriptions become formal. They also need to support visualizations in much simpler end-user process modeling languages that may even be ill-defined. A continuous, integrated maintenance of end-users' modeling expressions and modeling-experts' actual process models also faces new challenges. User knowledge encoded in these expressions may be less abstract and quite local to a certain usage context. While process models represent generalized 'global' descriptions that will be used by enterprise systems to provide their services, the management of modeling data needs to respect these local spheres and hide comments or other informal information of local groups from each other. Adaptive systems should also show these representations if usage problems occur where these descriptions can help end-users to analyze their own mistakes, to discuss necessary adaptation or use a service breakdown to find a new requirement for the further development of the systems.

8.6 Conclusion

Modern organizations will strongly rely on IT in general, and on adaptive service infrastructures in particular. Therefore, practitioners with little or no experience in formal process modeling will need to become involved in articulation, adaptation and (re-)design activities. However, current systems are mainly designed for use by modeling experts. In order to also involve users with none ore little experience in modeling, information systems need to be designed with sufficient flexibility as well as usability to enable end-users to (re-)model process descriptions [47]. While the choice of the abstraction level is crucial [126], visual metaphors can stimulate the excitement and attention of the user [97]. EUD approaches ease the process of service-(re)composition, e.g. FreEvolve platform [197] or Simple Service Orchestration (SISO) – a graphical BPEL editor for service orchestration [49], but still are designed for modeling experts. In comparison to previous work, we focus on the involvement of end-users, in the sense of domain experts with no or little experience in modeling. In order to also involve these persons in the process of flexible service adaptation, easy to understand process notations and interaction modes are necessary.

In knowledge work, processes are changing quite often, depending on the current context. Thus, easy ways to modify and comment on process descriptions are important. Our paper identified important aspects in supporting the articulation of current processes by the end-user. A case study with end users based on paper and pen indicated that besides formal aspects, informal process descriptions are of high importance. These findings underline earlier work [84, 101] by highlighting the necessity to express contextual issues through informal representations. In our case we were able to show, that the use of visual languages based on the box-and-wire metaphor are helpful, but even on a language level the provision of informal and localizable structures and even free-hand drawing may contribute to making sense of the work in practice. Based on recommendations for an end-user description language, we established a concept based on a pen and paper-based interaction mode for process modeling that adds to an open, creative atmosphere and supports different modes of collaboration. The information on the physical paper-based artifacts of the brainstorming sessions, is automatically recognized and transferred into a digital representation, including formal and informal elements. Both process representations are related to each other and establish a common ground by acting as a boundary object among the different stakeholders. As an important characteristic, the system also supports (re-)use. Based on an evaluation with real practitioners from SMEs, we were able to conduct a first evaluation study, which resulted in a number of improvements, such as better separation between a sketching mode and a recognition mode, or a more appropriate audio/video feedback during modeling sessions. As a further improvement, the system may allow end-users to indicate needs for changes and improvements (on the physical and the digital model as well), which automatically triggers notifications and proposed suggestions on the side of modeling-experts.

The studies and prototypes we described have to be considered as part of a larger research effort to prepare enterprise infrastructures in supporting their own continuous development. Activities of remodeling or reconfiguration do not only affect the technological level of an infrastructure, but they also contribute to process of making sense and the appropriation of these technological artifacts. This phenomenon is conceptualized as 'infrastructuring' [140]. When designing modeling languages, environments, and techniques for process specifications, these insights need to be considered to involve all levels of expertise (modeling and domain) in a better way and to include all types of experts and end-users. With our environment, we have taken a step in this direction.

9 Using Paper and Pen to Control Home-IT: Lessons Learned by Hands-On Experience[11]

Abstract

Standard remote controls are the most important interface to handle and control TV and media center systems for home entertainment. While the controlling device is being used as something statically, most providers now realize the flexibility of an interface on the software level at the controlled device. Such straightforward approaches reach their limits, when complex functionalities are to be handled remotely. Managing the media library, converting media items or entering text are examples of such enhanced options. In order to handle such complexity we experimented with smart remotes. In a first case study we explored the use of digital pen paper as a personalizable control device with enhanced text input capability. A prototype called p-Remote (personal remote) was implemented. The evaluation showed us that the users appreciate the possibility of being able to personalize the remote control interfaces, as they fully understand their own interfaces and they can have specific interfaces for different scenarios. The evaluation also showed that the p-Remote provides the user with a fast access and intuitive usage. By discussing the results, we will also point out several issues from which we have derived implications for designing smart remote control concepts in further work.

9.1 Introduction

The remote control has become one of the most frequently used interacting devices in households. As a device which is directly controlled by the user, the remote control should therefore be designed in a user-oriented way. However, remote controls nowadays are usually designed as an accessory to the main device according to the one button per function paradigm. Function overload of home entertainment devices makes button-based remote control a complicated and confusing user interface [16]. As a result, the users only use selected buttons of their remote controls, while the other buttons are used occasionally or even not at all [135]. Besides overstraining complexity of each single remote control, the users are always facing an awkward situation of having too many remote controls at home. This sometimes makes

[11]This chapter has been published as an paper in the proceedings of International interactive conference on Interactive television, 2011: Hess, J., Wan, L., Pipek, V. and Kuestermann, G. (2011) Using Paper and Pen to Control Home-IT: Lessons Learned by Hands-On Experience. In Proceedings of the 9th international interactive conference on Interactive television (EuroITV '11). ACM, New York, NY, USA, 203-212.

it difficult for the user to quickly identify the correct remote control for a certain device.

Additionally, the inefficiency of text input using standard remote controls is another concern. Although it may not seem serious now, the trend of traditional broadcasting media and Internet to merge will make this issue more and more important. As an example of this trend, PCs with a main function of media consumption, called Media Centers, are increasingly popular. Media Centers are designed to be located in the living room and connected to the TV. A Media Center system features a wide range of media functionalities including live TV, music archives, DVD playback and picture slideshow. Beyond local media consumption, Media Center systems also bring the Internet to the TV. Several solutions are availabe at the market, e.g. GoogleTV [12] or systems based on HbbTV [13]. While text input typically is not a needed function in conventional TVs, it is of great significance in current and future iTV systems, e.g. for entering a search phrase, entering messages or provide additional information for items in the media library. Nowadays, digital EPG, chat tools, channel recommendation and other social applications appear more and more often as an enhanced feature-set. Every of these functions has to be handled in one or the other way, e.g. by using standard Media Center remotes with multitap text-entry or by using multimedia keyboards. However, previous standard solutions are limited regarding flexibility, customizability and intuitive text entry.

Suffering from the low usability of standard remote controls, people feel a need and desire to design their own remote controls [16]. There are multi-functional remote controls on the market, called Universal Remote Controls, which can be reprogrammed to operate multiple devices. While simple solutions learn the commands from existing remotes and combine them into one device, more complex solutions, as e.g. the Pronto device [14], offer options to customize the interface at software level. As another alternative, remote control applications for smartphones become increasingly popular. However, reprogramming the buttons can be a complicated task for unexperienced users. More importantly, this sort of customization is limited to modifications on the software layout in a predefined manner. In this paper we focuss on a different approach based on digital pen-and-paper technology. In exploring the pros and cons of the pen-and-paper based approach, we want to extend the design space and also want to build ground for further

[12] HbbTV. (2011). http://www.hbbtv.org/

[13] GoogleTV. (2011). http://www.google.com/tv/index.html

[14] Philips Pronto. (2011). http://www.pronto.philips.com

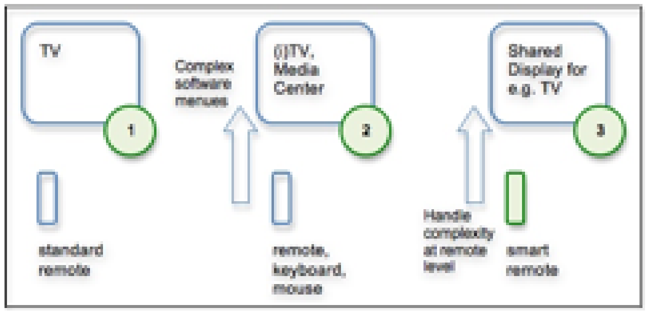

Figure 33: Standard vs. Smart Remotes

work in exploring and comparing alternative directions.

9.2 Smart remotes

The work we present in this paper is integrated in a long-term research strategy where we explore new kinds of input/output interfaces for media control and the social exchange in the domestic environment. In order to handle the complexity of the controlled interfaces, we have recognized a trend towards a more smarter control (as shown in Figure 33). In early days the TV set was exclusively used for watching TV. A standard remote for switching between channels or for controlling the volume was totally sufficient in those cases (Figure 33). Nowadays many more options can be chosen – managing the media library for Media Center systems or controlling enhanced functionalities for interactive television (iTV) are only two examples. While in most of the cases standard controls (as remote, keyboard or mouse) where used, the complexity of navigation and control is managed at the software level within the application (Figure 33). For the future we expect that systems – as TV, PC and Mobile – will be more and more interconnected with each other. The TV set will be transformed to a shared display for all kinds of digital media content (Figure 33). While content can be accessed from quite different sources, new kinds of smart remotes are neccesarry to lower the complexity and to personalize interfaces. A good example of a smart remote is the system developed by Cesar et al. [33]. In their work a secondary display is explored as an additional personal controlling device. Smart controls reach beyond traditional 'pressing button' forms, and also can make value of speech [13, 194], gestures [62] and everyday objects [7].

As a starting point for exploring new kinds of smart remotes, we have designed a pen-and-paper based remote control concept called p-Remote (personal remote). Because pen and paper are easy to use and have always been the well-accepted artifacts for entering text, we expect them to be an intuitively usable interface. As focus group, we concentrated on people who had more-than-average experience with new home technology (e.g. the user of a Media Center system). But in the long run, we also want to test those approaches with different target groups to check their acceptance. After implementing a prototype, which is briefly described as non-archival work in progress [85], we conducted a user study to identify the pros and cons of the concept. By testing the concept with real users, we also identified some important issues of designing such a remote control. We will present and discuss the identified implications, which are also of importance for further research work in related research domains.

9.3 Pen and paper interaction

The capability of digital pens to capture marks made on paper documents has opened a new area of interest in pen-and-paper based interactions. There are mainly two popular approaches in augmented pen-and-paper interactions. The first approach deals with the extension of digital activities on top of traditional pen and paper usage in drawing or writing. Examples include the a-book [119] and the ButterflyNet [201] for tasks such as the documentation during scientific research. Other research works such as the Audio Notebook [135] and the LiveScribe [15] made their contribution in integrating written notes with captured audio. The second approach deems the digital pen as a command-specification device, exploring innovative interaction interfaces. This command-centric approach is illustrated by research works such as the LeapFrog [16] (pen-based gaming), PADD [76] (augmented digital documents), PapierCraft [113] (gestures for editing printed documents), and the Print-n-link [129] (pen tapping for the retrieval of scientific citations).

Although many research studies have been carried out concerning innovative pen-and-paper based interactions, little focus has been drawn on bringing the pen-and-paper interface to the living room and using it as an alternative way of controlling the TV and its affiliated media center system. One related work is the augmented paper-based TV guide: Paper Remote [12]. Berglund et al. have shown that the paper and pen approach is intuitively usable and lowers the complexity at remote level. Therefore, their Paper Remote is a good example for a smart remote as described before. The solution from Berglund et al. works as an additional input concept

[15] Livescribe. 2010. Livescribe Inc. http://www.livescribe.com

[16] LeapFrog. 2011. LeapFrog Enterprises. http://www.leapfrog.com/

Figure 34: Concept of p-Remote

especially for the easy recording of TV shows rather than a standalone remote control device. Options for customization and text input were also not explored in that work.

9.4 P-remote

The digital pen technology makes it possible to digitalize handwriting input and transmit it to a computer via Bluetooth. The concept of p-Remote originated from the ordinary manner of how we write texts by using a pen to write on the paper. Different icons and symbols can be printed on the paper to create customized interfaces. As shown in Figure 34, icons with corresponding functions can be printed on the paper, which we then call remote cards. The user can slide different remote cards into a glass holder and then use the digital pen to tap on the icons in order to issue controlling commands to the media center, or to write on a certain text field to enter text. To change the remote cards is effortless and independent of whether the application is running. The users have the possibility to design their own remote control interfaces with a tool and print it out on the digital paper to generate personalized remote cards.

9.4.1 Pre-study

For a pre-study, we built a mockup of the p-Remote without implemented functionality. The prototype consisted of a glass holder and two sample remote cards (one for normal media control and one for handwriting text input). The card for media control included symbols for 48 TV stations, volume control (+, -as well as a free scale), program control (+, -), controlling cross (up, right, down, left) and colour controls (blue, yellow, green, red). On the backside there was a card for text input with an input field (three columns), a delete and a send button. Altogether 8 use tests with 8 participants (6 males and 2 females) were conducted. The participants were between 24 and 55 and who had used one to six standard remote controls at home. Each test began with a semi-structured interview in order to collect information about the participant's daily media consumption on TV and media center systems. Especially in our focus was the participant's experience with the remote controls. After that, the prototype mockup was shown to the user. The planned functions were explained as well. In the end, we asked the user a few questions about the design and his/her experience with it, so that we were able to polish the design during the implementation according the users' opinions.

As a result, we identified the program selection, the volume control, the mute/unmute, and the videotext as the most important functions of a remote control for the media center system. In reference to the already used standard remote controls, one participant complained that the most important buttons on the remote control were generally too small. So a possible customization of the remote control's interface was already requested during the interviews. After exploring the prototype, all of the participants had easily understood the concept of p-Remote. The feedback regarding the mockup ranged from 'not bad – however I have no demand' to 'great' or 'groovy thing'. Some of the participants criticized the size of the program and control symbols on the remote cards we provided. We then explained to them that they were able to design and customize their own remote cards, and so it was not considered a big issue. In addition, six of the participants were able to imagine that they would use the prototype for entering text messages One participant also requested additional functionalities including light control and remote control of the PC. Others requested in the same way for a universal remote to control both the DVD player and receiver. Also short games should be possible. The size of the glass holder was, however, criticized by most of the participants. A suggestion of making it narrower and longer for ease of holding was the prevalent opinion. The results of the pre-study were encouranging. Participants could handle the mockup very easily. We identified needs for customization and advanced media and home control. After the pre-study we began to implement the concept (see the next chapter). Also the feedback regarding the size of the remote was taken into account. A new glass mounting was designed that better would better met the participants‘ requests. But at this point, we also had to deal with a trade-off between the users‘ requests and feasibility – entering text becomes more difficult when the mounting is narrower and longer as requested (see right remote at Figure 34).

9.4.2 Implementation

The prototype was built based on the digital paper technology from Anoto [17]. The control mechanism has been realized through tipping or writing on the paper with a digital pen. The remote cards are actual digital papers with icons printed on them. Nevertheless, the number of possible remote cards is unlimited. The users are able to design and print out new interfaces to fit different usage contexts or personal preferences. The remote cards themselves are just as soft as ordinary paper. For sufficient stability and a better handling of the remote cards, we designed a glass holder. Otherwise the concept would not have worked out as intended – the paper would have bent while tipping or writing on it. By pulling cards in or out, the user can easily switch the card in use. Figure 35 shows a picture of the actual scene. Two remote cards are shown here: one for handwriting text input and the other for TV control. The hardware environment of this study contains a TV screen, a media center PC with Bluetooth connectivity, and the Anoto digital pen. The digital pen is digitalizes the user's action and sends the data to the PC in real time via Bluetooth. To make it possible for the user to control the media center system, a java application has been developed which runs on the media center PC. It receives the real-time data from the digital pen, analyzes the user intension, and issues corresponding commands to the media center application. The java application has been developed by using the PaperToolKit [202]. Provided with this event-driven platform, it is easy to create, debug and deploy digital pen-based applications.

Generating new remote cards takes two steps. First, the user uses the Adobe Acrobat [18] to edit a customized control interface. We have prepared all the icons as a resource in the Adobe Acrobat, including the symbols for all the TV channels of the country. These icons are nothing more special than the standard "stamps" in the Adobe Acrobat. The user can drag and drop these icons into his/her own layout. The user can easily reposition or resize the icons. If the user wants to have other styles of icons, it is just a merely additional effort to import new images into the Adobe Acrobat as

[17] Anoto AB. (2011). Anoto Technology. http://www.anoto.com

[18] Adobe Acrobat. (2011). Adobe Systems Incorporated. http://www.adobe.com/products/acrobat.html

Figure 35: A real scenario using the p-Remote

"stamps". In the second step the user needs to print out the layout on normal paper. An Adobe Acrobat plug-in, which comes with the PaperToolKit, will help do the print work. Besides of the user-designed interface, the plug-in additionally prints a barely-visible dot pattern on the paper as a background. This dot pattern enables the digital pen to identify the correct position and turns normal paper into digital paper. After these two steps, a new remote card is generated and ready to use.

9.5 Evaluation

In order to identify the user acceptance of the prototype, we ran a controlled user evaluation with 7 participants. The evaluation was conducted in a laboratory environment at the university. The environment simulated a typical living room with a TV screen connected to a media center PC. The test environment offered a comfortable atmosphere where participants were offered a seat in armchairs.

9.5.1 Participants

For evaluation we recruited 7 master and PhD students from the university, 3 females and 4 males. The technical skills are varying, but all of them were interested in exploring new technologies. The participants were between 22-32 years old and one of them was left-handed. All participants had computers and spent 3-12 hours per day working on them. All of the 7 participants used mobile phones. Six of them had T9-keypads on the mobile phone.

9.5.2 Method

To evaluate the p-Remote prototype, both a quantitative session and a qualitative session were conducted during the user test. The goal of the quantitative session was to verify whether the p-Remote is capable of operating a media center and whether text input is well-supported or not. This session was video-recorded under the users' permission. The activities on the screen of the media center PC were also video-recorded by means of a hardware screen recorder. Provided with these data we were able to measure the performance and error rate and then to compare them afterwards. The video-recording also allowed us to observe the body language of the users. A semi-structured interview was conducted in the qualitative session on the basis of a methodological framework informed by Grounded Theory methodology [179]. Overall each user test took about one hour on average. We analyzed the screen actions, the video recordings, the transcripts of the interviews, and the notes written down by our researchers afterwards.

9.5.3 Procedure

The participants were first introduced to the course of the test and encouraged to make themselves at home. At the beginning, an expert walkthrough of the media center application was conducted. The participants then had several minutes to explore the system. Also the user was given a standard remote control to control the media center. We observed that the media center application and the standard remote control were rather routine technologies for our participants, and after a few minutes of playing-around, all the participants were familiar with them. Next, the p-Remote was given to the users. The concept and functionalities were explained. As our participants had no previous experience in using the p-Remote and similar technology, they had time to become familiarized with the concept.

The user test began with a pre-defined to-do list that was related to basic media center controlling activities. The list included ordinary media center tasks such as: switching to a certain TV channel, searching and playing a certain music title from the music library, switching to another TV channel and activating the time shift functionality. The participants were asked to perform the tasks once with the provided standard remote control and once with the p-Remote. In order to minimize the learning effect, we switched the

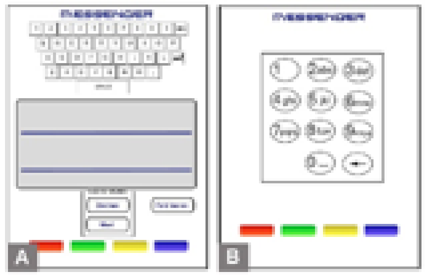

Figure 36: Predefined remote cards for the evaluation

order between using the standard remote control and using the p-Remote after each test. In this session, we measured the time needed for each user to finish the task list.

In the next session, the participants were asked to enter a short message with 50 letters. They were asked to enter the text in the following manner: 1. using the standard remote control with T9-layout to navigate through a virtual keyboard in the media center application; 2. using a remote card with T9-layout keypad on it; 3. using a remote card with a QWERTY-layout keyboard on it; 4. using handwritten input with a remote card that has a handwriting area. The card layouts are shown in Figure 36. In this session, both the time for finishing the task and the text input error rate were measured. The order of using the 4 approaches to enter the text message was randomly balanced among the participants.

In the last stage of the test, the participants were asked to personalize a remote card using the Adobe Acrobat. Participants moved to a workplace with the Adobe Acrobat application already running. A brief description of how to customize a layout was given to the user. As shown by Omojokun et al. [135] it is difficult for users to design remote controls from the scratch. In their paper based mockup study 7 out of the 10 users forgot to include at least one button that they actually used. Therefore it is important to provide the users with several default layouts, so that they do not have to build them from scratch. In our case we prepared those default layouts, which the participants used in the previous sessions. The participants could choose to build a totally new layout or customize default ones. As mentioned before, additional icons were provided as stamps in the Adobe Acrobat. In this case we asked the users to simply use the icons we provided, but they were informed and shown that they could actually use new icons.

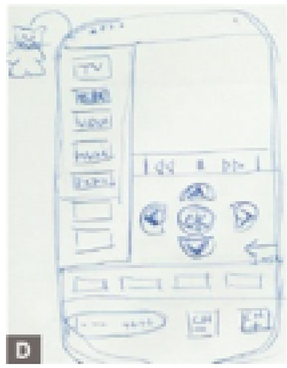

Figure 37: Sketch of a remote card layout drawn by a participant

9.5.4 Results

Customization

All 7 participants appreciated the possibility of designing new remote cards, and commented that changing the layout and resizing the icons were very important features. All participants expressed their ideas of how to personalize remote cards. One participant said that he would like to have several remote cards. Another participant wanted to design a remote card with only children channels for her son, to protect him from inappropriate content. However, only 3 of them picked up the mouse and made the changes in the Adobe Acrobat. The other 4 participants felt that it was still too complicated to cope with the tool and printing could also be problematic. For this reason, one participant chose to draw her preferred design directly on the paper (see Figure 37). This participant also asked for an individualized design of the glass holder. She preferred a holder with rhinestones and a pendant so that the device became a personal accessory. The predefined symbols at the p-Remote cards were also deemed as "not good-looking". One participant said that maybe "cooler" pictures could be used for the symbols, so that the p-Remote cards could even "decorate" the living room. The result shows that the participants liked the idea of making their own remote cards, but the majority of them hesitated to do so because of the complex customization tool.

Overall handling

Unlike the typical one-hand usage of the standard remote control, the p-Remote requires both hands – one for holding the glass holder and the other for controlling the functions or entering text via pen. We were interested in whether a two-hand use concept would be adapted in the living room

Figure 38: Handling of the p-Remote while entering text

context and how the overall handling may look like.

By analyzing the videos of the user tests we found, that usage of the pRemote results in quit different adoptions of holding and fixing both artifacts. Especially when it came to the text input evaluation all participants braced their arms in different ways (see Figure 38). While some were fixing the glass mounting on their legs or on the armchair, others reached a stable writing option by fixing the arm, which is using the pen.

Media functionality

The analysis of the processing time showed that all users completed the task list faster by using the p-Remote than by using the standard remote control. Table 1 shows the overall time for each participant to accomplish the task list. The time for using a standard remote control (blue) is compared to the time for using the p-Remote (red). The difference between the two controlling mechanisms varied from 16 seconds to 3:53 minutes. In the qualitative assessment, all users confirmed that they could fully control the media center by using the p-Remote. In particular, all participants gave positive comments on the p-Remote's design for using symbols for each TV channel. Likewise, the shortcut symbols to media modules (music, video, pictures, and etc.) in the media center system were also highly appreciated by the participants.

All participants performed better with the p-Remote. One obvious reason is the existence of shortcut icons, which reduces the time for some of our tasks (e.g. switching to the music module of the media center). A shortcut-enabled remote control (as p-Remote) provides fast adoption of a complex system used for the first time. While for some of the participants the time difference was small (e.g. user 6 and 7), for others the difference was enormous (e.g. user 1, 3 and 5). Nevertheless, the p-Remote is fully

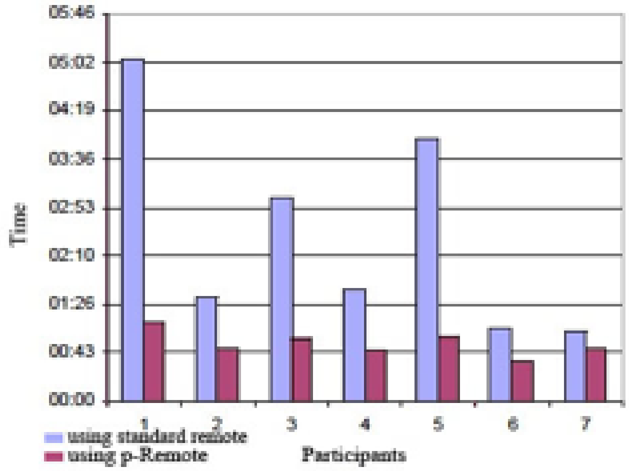

Figure 39: Overall time to accomplish tasks

capable of controlling the media center system, which is equally important as is the pure speed comparison.

Text input

Altogether 4 text input concepts were evaluated by measuring both the speed and correctness of text input (see Table 2). The results proved that text input via the standard remote control is the slowest way (16.34 Letters/Min), and also generates most errors (9.83 Errors). Using a remote card with a printed on T9-keypad is a bit faster (18.44 Letters/Min) and it generates fewer errors (8.5 Errors). Noticeably faster is the handwriting input using the p-Remote (51.9 Letters/Min), which reduces the error count is further (2 Errors). Our analysis showed that the use of the QWERTY-keyboard remote card achieved the fastest input speed (61.9 Letters/Min) and the fewest errors (0.33 Errors).

In the qualitative results, the acceptance of the 4 text input mechanisms varied considerably. The text input by using the standard remote control was rated very bad by the users - none of them preferred to enter text this way. They described this mechanism as “inconvenient”, “very annoying”, or “unusable”. The text input with the T9 keypad on the remote card required quite a long time, too. The multi-tap design was not convincing to the users and resulted in many errors. In contrast, the QWERTY-layout keyboard on the remote card was much better accepted. The participants commented that the p-Remote-version QWERTY keyboard is “much better” or “faster and accurate” compared to the T9-layout keypad. The handwriting input

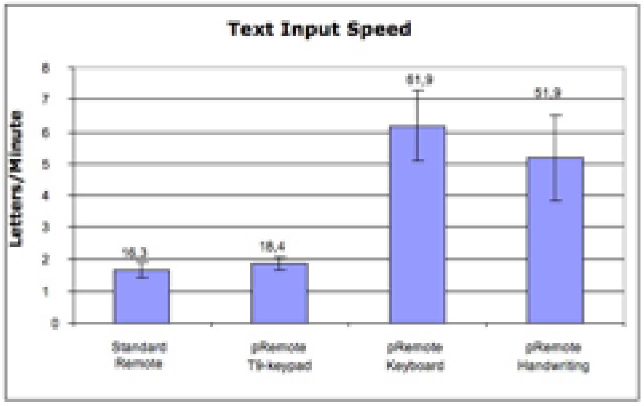

Figure 40: Text input speed

using the p-Remote has received an equally good assessment. The participants were satisfied with the speed and accuracy of the handwriting recognition. Furthermore, all 7 participants affirmed the intuitiveness of using a pen and paper to enter text.

Although the handwritten text input using the p-Remote is not as fast as using the QWERTY keyboard on the remote card, the performance gap is rather small. It is not surprising that the p-Remote-version of the QWERTY keyboard has the highest performance in text input. It is a simulation of the traditional keyboard, which is perhaps the best tool you could use for text input to the PC. But the traditional keyboard is not designed to be used in a distance from the screen, and is especially not suitable in the living room setting. As tipping with the stylus of the pen is a very accurate method, the keyboard layout on remote cards can be much smaller than in touchpad-based environments. Also, the fat finger problem is not an issue here.

9.6 Customization variations

By taking the evaluation results into account, we have modified the concept and developed an alternative design to replace the remote cards with remote stickers. One critique against the p-Remote concept was the difficulty in customizing a remote card. The Adobe Acrobat was deemed as "not usable enough" for the customization. And the user had to print out the layout on paper afterwards, which is also problematic for those who do not have a printer at home. In the sense of further reducing the customization difficulty,

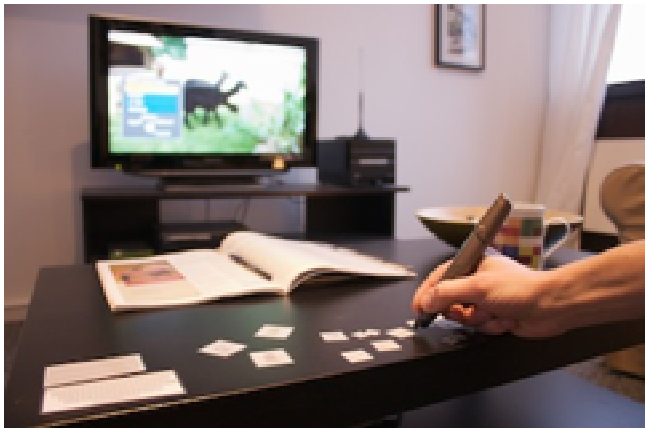

Figure 41: Remote stickers on a living room table

in the new design we printed out all the function symbols individually for the users. Each symbol was printed in two different sizes for the user to choose from. The symbols were encapsulated in plastic coating and were adhesive on the backside. The users could peel off the stickers from a booklet and stick them to any surface (see Figure 41). The sticker approach as an alternative customizsation method may further lower the technical threshold of the concept, as the technical details are better hidden from the users. No computer or printer are needed for customizing the interface, the only thing that needs to be done is peeling off the stickers and sticking them somewhere. It is worth mentioning that the QWERTY-layout keyboard is provided as one integrated sticker instead of single letters on the booklet. We also experimented with further alternatives including object recognition for the software designer. Rectangles can be drawn on the digital paper with a handwritten input of the command inside that should be executed. Drag Drop will change to Draw Drop in that case (see [7] for another use case in the domain of service orchestration). Several options are possible for virtual or real object-based customizations. However, finding an adequat option to customize smart remotes seems to be a research branch on its own.

9.7 Discussion

The border between TV and Internet is disappearing. Our research group was inspired by the spirit of TV 2.0 and took TV-centric social aspects under the spotlight of the running project. Around TV watching there will be more and more "PC affiliated" activities, e.g. entering text for chatting with friends who watch the same TV program. We explored an alternative remote control concept using the digital pen-and-paper technology in order to experiment the possibility of offering customization and better text input ability to remote controlling devices. With regard to the concept, there has been a lot of discussion during the evaluation tests. As researchers we really appreciated the discussion, which will help us to explore the important issues.

9.7.1 P-remote versus wireless keyboard

As we tested a QWERTY-layout keyboard on the remote card during the evaluation, one quite natural question would arise: why not just use a wireless keyboard? Historically, since mouse and keyboard first appeared, there have been discussions about the "focus disconnection". That means we control a device at one place (e.g. mouse), but check the result at another (e.g. screen). This problem is not that significant on desktop computers or laptops, because of the relatively short distance from the screen to the mouse or the keyboard. But this circumstance becomes an issue when entering other domains where devices are controlled remotely.

In the living room context the problem of focus disconnection by using a wireless mouse and keyboard can be huge. The distance between the TV and the couch is normally several meters, and this makes the disconnection much more significant than the desktop case. The concept of p-Remote faces the problem of focus disconnection, too. While it is light and handy, we expected the users to hold it higher and to keep it in between the sight line to the TV. But this expectation was not met in the evaluation. The participants used the p-Remote in height of the knee instead of the height of the eye-TV line. This aspect gave no advantages compared to media center keyboards.

Another important factor to consider is the dilemma between "lean-back" and "lean-forward". Keyboard, no matter wireless or not, is a typical lean-forward device. The size determines that the best usage of a keyboard is to put it on the table and then to type on it. Of course, a wireless keyboard can be used on the laps in a lean-back position. In reference to this aspect, the p-Remote performed in a more relaxed mode because four of the participants used it rather in a lean-back manner (see Figure 38). Such a behavior is much more suitable in the living room context.

9.7.2 Haptic

An advantage of standard remote controls is the haptic manner of the buttons. After using a remote control for several days, most users are able to find the most often used buttons on the remote control just by haptic sense. When the user pushes a button on the remote control, the haptic feedback of the bouncing back confirms the execution of the command. In this sense, haptic on a remote control is important for two reasons: to find the right button and to get (additional) feedback for execution (the state change on the controlled main device is the primary feedback).

As a concept built upon paper, a lack of haptic feedback automatically comes with the p-Remote. It is difficult to locate a button on the remote card correctly without looking at it. However, as the users are able to design and generate their own remote cards, they should be quite familiar with those personalized cards. Some participants of the evaluation said that they would only put most useful buttons on their own card, or they would use bigger size for those important buttons. This would help the user to better locate the right button, but would not enable a haptic experience. A solution for that issue would be a physical positioning of the most important buttons directly on the pen (e.g. channel zapping by pressing the mine in/out button at the end of the pen). Additionally, a key tone could be played when the user clicks any button on the remote card, which serves as an alternative feedback mechanism.

9.7.3 One hand or two hands

The p-Remote has to be operated by using both hands, one hand holding the glass mounting and the other holding the pen. This is quite different from using a standard remote control, which only requires one hand. This circumstance has been criticized by some of the participants. Two participants suggested a transformation of the concept on a touch-screen handset (e.g. iPhone), so that they could operate it with only one hand. Another concern is that this design only works, when both artifacts (glass mounting and digital pen) are used in parallel. If the pen gets lost, then the system does not work anymore. But designing a remote control should count in this fact. If more than one artifact is being used, then a design concept is necessary for holding them together (e.g. pen holder). Alternatively, the remote concept should be designed as a single object, but not as a combination of objects.

9.7.4 Visibility

Another disadvantage of paper is the bad visibility in low light conditions. That means the p-Remote also has this problem. Low light situation is not a rare case in the living room context (e.g. watching DVD). Standard remote controls have this problem, too. But depending on haptic sense, "familiar" users can use their remote controls with no problem; at least they can access the most frequently used buttons quite easily with the "haptic memory". As the p-Remote concept lacks haptic sense for users to locate the buttons, it may be somehow problematic to be used in dark conditions. Further work should look into the possibility of providing backlight to the prototype, or build the prototype upon some device, which is self-illuminating (e.g. Smartphone).

9.7.5 Customization

The functionality of customizing the remote control was appreciated by all of the participants. However, the concrete implementation provided by the p-Remote concept was not as practical and easy as it should be. Using the Adobe Acrobat plug-in and a printer to design and generate custom remote cards is too complicated. Despite all learning efforts, to personalize or design a new remote card the user needs to install Adobe Acrobat Professional, the Acrobat plug-in and a printer. But even without the workload of installation and the print process the use of the drag drop software was difficult. The design of an easy to use customization procedure is an issue here. One of our participants mentioned that she really liked the idea of designing personalized remote cards, but preferred to draw the design on paper instead of using the plug-in. But such an approach is only of interest in the design phase. We asked about the option of using self-drawn symbols as remote control buttons, and the participants reacted skeptical to this alternative. They preferred nicely designed icons because their own craftsmanship was not good enough for that task. In our further research we should find easy and intuitive ways to enable users to customize their controls.

9.7.6 Paper-based interfaces for Home-IT

Our research started with a strong orientation at the use of classical remote controls. But the characteristics of paper-based interfaces have not been fully explored. We have an interface based on a material that is very cheap to reproduce and has various options to be formed and placed in its environment. Extending our research domain for this kind of 'remote controls' beyond media centers to other home devices and appliances (e.g. dishwasher, shades), we envision a number of different modes to design interactions around this interface.

Multiple controls for one device: With the digitalization of all kinds of devices, many of these get more functionalities and become more customizable. Many users (e.g. children, people with dementia or muscular dysfunctions) will, nevertheless, only need particular, simple interactions with these devices, but maybe controls that are very big or comprehensible. For every user group for a device, very diverse user interfaces can be developed at very low costs. Along the same practice one could think about temporal interfaces that work e.g. in connection with an event.

Located controls: The pen is the input device, while the navigation information is externalized on paper. The paper can be placed at/glued to locations in the household that are particularly appropriate for the interactions or controls drawn on the paper. These 'input stickers' can turn living environments in ambient interfaces at very low costs.

Extensible interfaces: Several sheets of papers can be combined to form a large interface. Considerations of screen real estate can be different here compared to screen-based interfaces. Visualizing a large number of controls does not lead to a necessity to scroll or to decide for smaller controls. It is also fairly easy to physically extend existing interfaces.

Foldable interfaces: Although large interfaces are possible, their storage is does not occupy the same space as user interface does during operation. Paper interfaces could be folded and stowed away. In many scenarios, touchscreen interfaces may provide similar interaction logics, but touchscreens would be much more expensive, as a remote control heavy and bulky to be carried around (compared to the pen as the part of the input device that users need to carry around for paper-based interfaces). Paper-based interfaces have a number of shortcomings when compared to touchscreen solutions, but they are definitely worth to be explored for several specific situations.

9.8 Summary and future work

In our work we explored the concept of using the digital pen paper as a customizable controlling device with enhanced text input ability for the Home-IT. We developed p-Remote – a customizable pen-and-paper based remote control for the media center system. The evaluation of the prototype has shown that users are able to use the p-Remote to control the media center system with no difficulty and in some cases even faster than by using a standard remote control. Text input using the p-Remote is proven to be much faster than using a standard remote control. The users appreciated the possibility to design and generate personalized remote cards. The evaluation also pointed out some important issues, which we take as design implications for our further research work in designing alternative remote control concepts:

- It should be a light and handy device that can be operated with one hand. This requires the device to be one object, but not a combination of objects. Alternatively, an attached pen could be an additional option for fast and accurate text input capabilities.
- It should better provide haptic sense and feedback. If not, provide audio or other kinds of feedback instead.
- It should be self-illuminating so that it can be used in low light conditions.
- It should provide the users with the possibility of personalizing the interface, but customization itself should be user-friendly.
- It should provide shortcuts to the most important functionalities of the system. Users should be able to define own shortcuts or combinations of commands.

Our further development will bring the concept to the multitouch digital table (as a secondary shared device) and to the Smartphone (as a secondary personal device). Touchscreen technology enables the both options to be used with one hand and under dark conditions. Additionally, these options have built-in text input and Internet capability. This could bring in other interesting scenarios, e.g. content sensitive interface, visual feedback or social aspects. However, issues related to the overall handling and easy-to-use options for customization still remain. Another important aspect for further work is the comparison between different customization and controlling modalities. A profound understanding of pros and cons related with each technology also may lead to more integrated approaches that bridge between several media devices and appliances, e.g. design on paper, customize on large screen, share and use on personal screens. The options we described for highly individualisable, locatable, extensible and foldable interfaces will sustain our lasting interest into this technology.

10 Implications for Design

10.1 Reflecting co-design activities of home technologies

Results in this thesis provide detailed insight into how infrastructuring of home technologies can be managed in a more open, distributed and continuous manner. The study of a co-design process with users from an online community showed that distributed participation, from the initial design stages to the final product, is manageable. But the results, reflected in detail in chapter 4, also shed light on several issues regarding organizational and technical aspects. In another case study, users from local households were involved to co-design a similar system (see chapter 5). In contrast to the distributed case, the organization of the local co-design process included face-to-face meetings and empirical studies that enabled detailed insight into household practices and routines. Methods of self-documentation had been used as the first step of empirical exploration. The results from both studies show the potential of long-term cooperation with local households and members from online communities as well, but results also refer to several issues to be addressed in further work. Within this chapter, the most relevant findings are discussed in respect to the research questions described in chapter 1.3.

10.1.1 Co-design with users of an online community

The concept of a community-driven development differs from existing studies [64, 151] in that users contribute to the design process from the early phase of defining the requirements for a new product. Furthermore, the decision process is framed in a highly democratic way whereby the user representatives are involved in a decision committee and decide on the functionalities to be implemented by the company. As shown in earlier studies, online communities are a valuable source for PD activities [150]. The participants in the case study presented here provided new and interesting ideas at the very beginning of the design phase. This early participation in turn led to an increase in user motivation regarding the testing and evaluation of prototypes. The usage of social technologies such as email and online forums resulted in very flexible, distributed participation discourses (similar to the findings in [54, 64]). Applying participatory design in the wild comes with several advantages, including stimulation of participation by involving many users, direct communication and information exchange between various stakeholders, and direct feedback regarding prototypes. However, the study also raised several issues, as addressed in the following sub-chapters.

What are the limitations of a co-design process with users from an online community?

The case study with users of an online community provides detailed insight into how a software system can be co-designed with users from an online-community. Compared to previous approaches (e.g.[64]), users really had an influence in deciding on certain functionalities which is similar to democratic PD approaches for the workplace [37]. What started as a highly democratic experiment became problematic to a certain extent. Users could not invest as much time as necessary, responsibilities were not always clear, developers avoided participation, management exerted time pressure regarding release start etc. Considering these issues during the design process, users and employees alike rated this approach as not appropriate for a complete new development. It was shown that the heterogeneity of wishes, ideas and improvements was not well balanced enough for the development of a first basic version. In the following quotation, one involved employee clearly points out the overall experience with this approach.

> *"Well in general I think user-driven development is only good as a method when I'm involved in the further development of existing software, i.e. making variations, making new versions. I think it is probably not very suitable for developing from scratch ... Of course, it works fine with niche products ... But especially where small products are concerned, I think it's an excellent method for motivating the commitment of the users." (involved employee)*

Two major points are made in the above statement: the co-design process would run more smoothly with software already in existence (even if some basic pre-conditions on the software would need to be accepted), and in case of designing niche products with an active online community (mass market versus niche product for special interest purpose). The media center developed in the study was a completely new software product. Basic architecture and functionalities needed to be developed from scratch, which resulted in long delays. Previous software products were extended step-by-step, which proved to be a more adequate form of development.

A second aspect that was been shown to be important is the target group for which a new software system is developed. In the case presented, a niche product (media center system) was developed with the involvement of an already established, active product community. Especially at the beginning, users were highly motivated to contribute their experience as they were already familiar with the existing software version. The users had clear expectations of which functions had to be realized that were not available in existing standard market technology. The identification and implementation of specific features considering the respective peer group can be better addressed with community-driven development. However, designing new features without a basic version seemed less than optimal, due to the lack of focused discussion and a too broad field of interests. Additionally, the implementation of the basic system would require more time.

What motivates a company to establish end users to participate in a co-design process with an online community?

The initial motivation of the company was to define a system with a unique selling point, a system that differentiates from existing solutions on the market. When the project started, the market of media center systems was dominated by 'standard solutions'. Obviously the new media center system to be developed would have to be different. The participants in the very active online community continuously asked for a variety of specific functionalities, e.g. to sort large archives of music or to adequately visualize online information on the TV. The development of a complete new media center system, with an open interfaces architecture was seen as an opportunity to address these requirements for a potentially successful product. Additionally, the co-design process was actively promoted in press releases and newsletters in order to increase awareness of the new product at a very early stage. Within the project team itself, different attitudes on the shared participation could be observed. The product management focused on the range of possibilities opened up by such active community involvement. On the other hand, the developers regarded the community-driven process with suspicion, as they were not used to framing technical aspects dynamically during a project.

The study also evaluated the motivation of users to contribute in co-design processes. According to the findings of Jepessen [150], users are basically intrinsically motivated. Their participation is often part of their leisure time activities as it tallies with their interests. Jepessen's study also showed that recognition, especially from members of the product company, provided strong motivation, encouraging users to contribute. This motivation, however, could not be observed in the study with the community-driven development. The users primarily contributed in order to address their needs in terms of the functionality of the software. The users were dissatisfied with existing standard solution and focused their interest on such different co-design topics as specific functionalities or features, or on usability, stability and design in general.

The optimization of existing software was the predominant aim of the participants. Especially at the beginning of the project, users were highly motivated to contribute their own ideas. In the course of the study however, the degree of motivation varied. The highest motivation level could be observed after the release of new demo or alpha versions. Many users downloaded these versions, tested them on their systems and provided short feedback in the forum. This volatility of motivation during the entire study can also be explained by the perceived workload for the participant, when leisure activities assume the character of work. Discussion threads from the other users in the forum had to be followed, participation in weekly calls was expected and the results had to be reflected. Also, the time constraints of the user representatives did not leave as much time as would have been required.

What are the major issues when allocating the main responsibilities among user representatives within the co-design process?

The design and development process involving an online community was initiated by a company which already had experience with close user cooperation. They were already used to considering ideas from users of an active online community. By initiating the community-driven case, the situation was different: members of the online community were given the responsibility to decide on the concrete functionalities for a complete new release of the software. When the project started, the company had not been aware of the challenges of managing a PD process with a heterogeneous group of users.

Compared to the study by Fueller et al. [64] wherein users can also contribute new ideas, the design and decision process for a community-driven development approach is more transparent. User representatives and employees discussed the feedback from the forum, made joint decisions and published the requirements in a wiki system. Thus moderators have significant influence on the decision-making process as they filter all information from public discussions. Different levels of experience, varying interest and time to contribute made this approach difficult to handle. The workload for the moderators as mediators between users and developers increased significantly and lost its leisure time character, which also had a negative impact on the steering process. During the study, the structures of professionalization led to an unintended power imbalance on the designer's side. The product manager, as the person with most experience in project management, took control of organizing and structuring the process, by contributing with own ideas in the public forum, by structuring the weekly Telco, by publishing the results in the wiki and also by communicating news from the development.

The study demonstrated that it is difficult to realize democratic decision-making in practice as ultimately company interests will dominate and not all input from the users can be adopted. Instead of just collecting ideas and improvements, e.g. in reference to a visual web demo, community-driven development is related to the issue of balancing the impact of different needs, ideas and requirements. Different experience, knowledge and background lead to a variety of aspects and requests, e.g. certain functionality, or improved usability. Such a wide variety of feedback can be problematic when only a small subset of functionalities can be implemented in a basic system. The study also showed that most active users influence decisions more than averagely. A steering committee staffed with user representatives and employees then need to find adequate formats of management, e.g. to let user representatives within the steering committee rotate regularly, to make discussion on decisions more visible (not only the results of discussion), and to better link feature requests with decision support.

What impact do social technologies have on the organization of such a design process?

The aggregation of data in the steering committee and also the evaluation of the decisions were not optimally represented. The full transparency intended and requested by the user was not given. Decision-making itself took place in weekly calls and afterwards the results were published in the wiki system. However, the call itself was not public. The wiki system was neither well integrated nor linked to the discussion forum. There was no platform, accessible to all users to enable optimal discussion and reflection. The existing online tools (web forum and wiki) had been shown to be unsuitable for this highly dynamic participation processes. Users thus requested that steering committee meetings be made public (e.g. via web conference, or that they be downloaded and accessible later). They also demanded further feedback cycles (e.g. by voting on decisions).

When the company released the first alpha version some months after the project started, users who had actively contributed from the beginning were dissatisfied. Not all feature requests had been implemented, and development had taken longer than expected. Social technologies had not supported the process in an optimal way, with the exception of in management issues.

At various stages of the project, participants requested tool support for better and integrated forms of feedback and reflection. For example, to make some form of visual prototyping possible at the beginning of the process. In the course of the project, requests were made for better technologies in order to improve the link between discussion (forum) and decisions (wiki), and also later on to better provide feedback regarding the alpha version (e.g. integrated feedback options).

An initial solution for better linking usage to the feedback process was provided by an additional rating module which was integrated into the prototype. After each module had been started three times (e.g. to manage images, to watch television or to listen to the radio), a rating dialogue was displayed on the interface, enabling users to rate the functionality, the design and the usability. Feedback was collected remotely and analyzed in a short summary. Although this feedback was necessary for a general understanding of the level of satisfaction, a more profound understanding of the details was still necessary, e.g. why the usability of a certain module was rated negatively. For further such development processes, both users and employees requested easy-to-use feedback channels, capturing the context and enabling more detailed descriptions.

10.1.2 Co-design with users of local households

In order to co-design for the domestic environment, the Living Lab approach provides a valuable frame for the structure and organization of the participation process of various stakeholders in a timely manner. The involvement of users with a long-term perspective offers several advantages compared to single PD activities that only take place in one single design step. Returning participants, in the sense of informed participants, can provide more detailed feedback [180]. In the case presented in this work (see 4), co-design took place step by step, starting with an empirical exploration of the context and the subsequent design of mock-ups followed by creative reflection workshops. The background work includes a profound understanding of how technology is embedded in daily life. In the Living Lab study, self-documentation methods combined with interviews and creative workshops helped to inform the infrastructuring process of a media center system. The major aspect which has to be mentioned here is the deep insight gained in working directly with households, compared to an anonymous online community.

Which differences arise when applying a co-design process with users from an online community compared to a process with local

households?

Co-design studies can be applied in different ways: integrating users remotely, face-to-face, and by using different environments (e.g. stationary lab, real households, online platform) and tools (e.g. self-reporting methods, observational techniques etc.). As shown in the case study involving an online community in co-design, the use of social technologies enables the involvement of a broad user sample, and also enables the participation of predefined target groups without geographical limitations. Furthermore, this facilitates early prototype testing by providing a download link and opens up space for reflection. Designing with local households differs in certain aspects. Compared to a PD approach with users of an online community, users are not necessarily experienced within the product domain, and PD activities take place face-to-face, knowing the user demographics and household structure. This approach is much more in line with traditional forms of PD in workplace settings [24, 25], referencing mutual learning process and active participation of user representatives.

The co-design study with users from local households took place with a more profound empirical understanding of the context, and included aspects of how technology is embedded in daily life, of the social relationship between participants, and the technical infrastructure. Such knowledge helped to rate different aspects of functionality with a more profound impact, e.g. by understanding to what extent functionalities are used, and how functionalities are embedded in daily life. Ideas were discussed in creative workshops based on previous technical experience. The technically more experienced users provided new ideas regarding state-of-the-art technology. In comparison to the co-design study with users from an online community, ideas were reflected in a more basic, practical and comprehensible way for all members of the households.

Ideas for new features evolved dynamically, from the diary study, interviews and workshops, and were discussed afterwards by the project team. In contrast to the co-design study with the online community, the participants had no influence on the decision process, which was exactly as intended. The user feedback was evaluated and respectively considered for development. During the project the users formed a kind of community of practice. Co-designing with users developed into an interactive process in discussing features face-to-face and also e.g. by sketching in the creative workshops. The profound empirical understanding of the context, the personal contact to the households and the common design and evaluation activities helped to co-design in a structured and continuous long-term manner.

10.2 Tools that support co-design activities

The concept of infrastructuring explicitly addresses tool support for all stakeholders' activities that contribute to the establishment of information systems [170]. The tools presented in chapter 6, 7, 8 and 9 are toolkits that allow the recording of breakdowns and use innovations within the surrounding environment. Such mediation is necessary in order to link users and de-signers. Users can reference different IT-based requests, e.g. to report a software bug or hardware problem, to document missing functionality, or to describe new requirements and ideas. Non-IT based aspects can also be of relevance, e.g. when linked to the physical setting, or in reference to the culture of using technologies. Infrastructuring toolkits support resonance and in-situ design activities on the users' side. This chapter reflects the design and evaluation of these toolkits, including infrastructure probes (see chapter 6), a cross-platform feedback tool (see chapter 7), and digital pen based concepts that support modelling and design in-situ (see chapter 8 and 9).

10.2.1 Infrastructure Probes

How can feedback processes be stimulated with regard to design issues in use contexts?

Cultural probes originally introduced by Gaver et al. [65] enable users to self-document thoughts, visions and ideas. The aim of the infrastructure probes is a more infrastructural perspective. Users become aware of problems or possible improvements in case of breakdowns or if something does not work as intended. In order to document such cases and make them visible for design and development, users should have opportunities to document and annotate directly in context of use. While this practice is incident-based, there is a necessity for adequate tools to enable a routine process. The infrastructure probes were designed to be used in-situ, meaning that if a situation occurs that needs to be dealt with, e.g. a bug has to be reported, a work-around has to be described or a missing functionality has to be reported. By using the snapshot tool, screenshots can be made and commented on which aids design and development to understand the technical and organizational issues users had to deal with in everyday practice.

Results of the evaluation showed that infrastructure probes could provide added value to empirical work. Participants reported concrete examples of breakdown situations and problems that could be discussed later on in the interviews in more detail. These examples helped to make the working infrastructure more visible, and from the designers side to become aware of problems and potential improvements.

As learned from the study, users focused on an easy and intuitive use combined with the strong extrinsic motivation of getting something in return; a personal benefit. A second important aspect is the frequency for applying such user studies with probes. The infrastructure probes were used as the first step in investigating the practice and to learn from the domain via self-reporting. The evaluation showed that users were initially more engaged and therefore more likely to participate in the first study compared to the second one. The first contact with the probes would seem to be very important, in the sense of an interesting try-out situation, in the sense of experimenting and documenting, and also considering that the users expected to receive feedback (e.g. receiving help or an improved version) in return.

As shown in a previous study [95], the diary method can be used to identify interesting markers that can be discussed later on in more detail. Since identifying such markers via observation and interviews alone is extremely time consuming, diary and probes studies are an important and valuable step towards understanding the context in question. The documented markers can be used as a reference for remembering a certain situation and link, for example a follow-up interview in a certain context. Such self-documentation studies also are valuable for trust building, and domestic space can be explored with caution. As confirmed by the results of the co-design study with local households (see chapter 5), feedback from the diaries and the cameras enriched the results of the interview and provided a detailed empirical understanding of the usage practice. The documentation boxes also helped to sensitize the participants for the research project, providing a concrete how-to example. Compared to the infrastructure probes, the diary and cameras were better adopted by the users. This could be explained by the different context: work versus domestic setting, obligation of users to participate versus voluntary participation. Another influence is the variation in use motivation: documenting 'events' (possible improvements and breakdowns) versus documenting everyday practice of using technology.

10.2.2 Cross Platform Feedback tool

What are the requirements and design implications for feedback options that are integrated in usage practice?

Feedback cycles are important to evaluate and continuously improve a software system. The co-design study with users from an online community had shown that standard web tools such as online forums and wiki are not sufficient to enable respective user articulation and a satisfying decision process considering the high flexibly of the development processes. Requirements entered in text form are not easy to interpret per se. The individual use of different threads and subcategories is another challenge regarding the channeling of relevant information. The demand from both the company and the user for more integrated and continuous feedback channels is understandable. See quote below:

> *"What would definitely be helpful is a kind of ... feature request tool within the software. That means ... an opportunity to use shortcuts ... exactly at this point a screenshot could be captured and then attached to an e-mail ... so that users would not have the problem anymore of having to explain what they actually mean ... because they always focus on a detail ... and we do not always fully understand what they mean, . . . " (employee of the company)*

In comparison to isolated technologies, such as forums, wiki and mail support, feedback tools allow users to submit feedback directly in reference to the functionality and related to the usage context. The snapshot tool from the infrastructure probes and the feedback tool (described in chapters 6 and 7) are initial solutions towards addressing more contextualized feedback (in-situ). Evaluating the work context, it became obvious that such tools need to be as easy and as intuitive to use as possible. The previously mentioned snapshot tool partly was too difficult to adapt (installed on a USB stick, needed to started every time, needed to be learnt). This was the major barrier which hindered it from being to established among the employees. The concept of a cross-platform feedback tool goes beyond a single feedback channel. Such an 'always-on' opportunity enables users to report issues and requirements in context of use, to make a screenshot from every device, and to annotate and share.

The vision of a ubiquitous feedback infrastructure includes media channels that enable feedback cycles to all parts of the socio-technical environment. Depending on the context, feedback channels can be linked among the users, e.g. to provide help or tips and tricks, but also and more importantly between users and designers/developers to continuously improve the system. Further work may explore the potential of an interconnected approach that enables feedback, for example in the form of a screenshot, from every technical platform. In a further step, users who have the same or similar home infrastructures could be linked with each other to provide the best practice examples. Related aspects like reward programs or playful stimulation also seems to be relevant subjects for further works.

10.2.3 Digital pen based interaction concepts

How can digital pen technology support non-expert users in adapting systems in-situ?

The workings on pen-and paper-based interfaces were motivated by the question of how non-expert users can adapt information systems by sketching, capturing, and mapping virtual representations. There are several approaches that made use of digital pens for certain tasks, e.g. to support scientific documentation [119, 200], to augment digital documents [76] or used in combination with speech [145]. But the usage of this technology as a sketching based toolkit for infrastructuring activities had not been considered thus far. The cases presented in this thesis adopt the digital pen technology in two domains: a sketching tool to support process modelling in a business context and a personalized remote control to design individual layouts and to interact with home technology. Both concepts have in common that paper-based interfaces trigger virtual functionalities. Non-expert users are supported in adapting a system and in interacting intuitively.

The modelling case especially supports collaborative brainstorming. By using more than one pen, a group of users can work synchronously on a process model. Regarding the infrastructuring approach, the concept provides two main advantages compared to an expert-driven design: collaborative modelling of an existing infrastructure and opportunities to easily adapt the model when the infrastructure changes. The resulting representation is a collaboratively-generated representation of how a group of people work and interact in practice. This bottom-up method provides professional designers with valuable insights on current practices and also identifies potential for improvement. The model, generated by the users involved in the processes, is also a flexible snapshot of the current work situation. In further work, such models may be connected to a system where a productive system is directly adapted in-situ according to changes done on the paper.

The remote control approach is another example that shows the potential of digital pen technology as a toolkit for infrastructuring. With this concept, each user can design his or her own remote control layouts and trigger digital functionalities in home technology. Instead of adapting a system with standard remote controls, users can easily personalize their controls by choosing and arranging graphical icons. This example can be transferred to any services in the home context facilitating the in-situ adaptation of (complex) technologies. The sharing of layouts among users is another interesting use-case to explore further, e.g. to recommend content and services to special interest communities.

10.3 Involving Non-Expert Users in Co-Design: Towards an integrated infrastructuring perspective

Depending on the context, users who are involved in design activities can be categorized as lead users (known from marketing literature, users who are aware of upcoming trends, see e.g. [149]), end users (known from research on end user development, users customize systems themselves, see [159]), casual users (a more generic term for users who are interested in new smart technologies, see e.g. [31]), key users (users who are specialized in a certain aspect of software systems and who act as a contact person), or more generally as user representatives [25]. User representatives influence the design by discussing and reflecting with a development team, e.g. they provide new ideas and visions, reflect on scenarios or visual mock-ups or evaluate prototypes in practice. All PD activities can be organized in project groups, where mutual learning takes place between different stakeholders, user representatives, designers, and managers [24]. Genuine participation has been referenced as an ongoing process to learn practices and insight from each other.

Several participatory design oriented methods like user-centred design [128], contextual design [18] or experience design [172] try to anticipate and design for use before it has taken place [51]. The concept of infrastructuring provides a more detailed understanding of all relevant design activities before and during use. Technologies are embedded in more complex infrastructures and work cultures [170]. Activities for infrastructuring [170] are characterized by continuous reflection and improvement, and by adaptation to personal and also changing needs. From the perspective of users, there are needs to adapt a given infrastructure as soon as something does not work as indented or when tasks cannot be fulfilled in a satisfying manner.

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Several participatory design-oriented methods such as user-centered design [128], contextual design [18] and experience design [172] try to anticipate and design for use before use has actually taken place [51]. The concept of infrastructuring [170] provides a more detailed understanding of all relevant design activities before and during use. Technologies are embedded in more complex infrastructures and work cultures. Activities for infrastructuring are characterized by continuous reflection and improvement, and by adaptation to personal and also changing needs. From a user perspective, the necessity to adapt a given infrastructure arises as soon as something does not work as intended, or when tasks cannot be fulfilled in a satisfying manner. Non-expert users then try to get help or start to search for a new product that better addresses certain requirements.

Providers of software systems are forced to react more flexibly to the needs of the users by improving products continuously. Such an integrated design and development progress requires flexible processes to better include users in co-design activities. Companies are becoming increasingly aware of the value of more flexible co-development (see e.g. [151, 150]). Compared to standard software development that focuses on a 'design before use' [51], an integrated infrastructuring perspective enables 'continuous design in use' which needs to be supported by a process- and tool-oriented stance as well, e.g. by offering integrated feedback channels, by collecting feature requests, and by updating services frequently.

10.3.1 Processes-oriented view

Reflecting the findings from the two co-design studies with users of an online community and with local households, a methodology implication is the combination of both in order to benefit from the various advantages. A moderated co-design process with a small number of users in early design stages provides several advantages, e.g. cost reduction in avoiding unnecessary adaptation cycles [31]. But as shown in the co-design study with local households (see chapter 5), a process of mutual learning [25] requires more than just forming a project team and reflecting the ideas. The concept of Living Lab goes beyond a 'single-user study' design as the users are involved in a far more integrated and long-term manner [60]. In order to co-design with a more practice-based view, local households participate at different levels e.g. to exchange their thoughts on current practice or to provide new ideas. Compared to co-design involving users from an online community, the process of identifying ideas and potential improvements can be applied in a more detailed and reflective manner. Information about demographics, technical infrastructure and usage behavior leads to a more profound understanding of interesting and valuable features for a new product. Early design concepts are discussed face-to-face within a group of users who already know each other. As the early prototypes are installed in the homes, this generates profound insight into the reasons for using or not using a system.

The evaluation of an early prototype within an online community also shows several advantages as a larger group of interested users can be addressed and a wide variety of feedback is collected. For the first stable basic product, the community users are encouraged to continuously contribute feature requests and bug reports. Different testing conditions from a technical perspective provide valuable feedback for further development. The results from the co-design study in this context (see chapter 4) have shown that this kind of distributed approach is especially suitable for the special interest products of an active online community.

An integrated co-design perspective includes user involvement in varying forms and environments, e.g. the direct cooperation with local households or online communities. As shown in the studies, the mediation between different sub-goals, also referenced as the design paradoxes [50], is one of the main issues to be considered. Results have shown that giving users full responsibility in the decision process is not an optimal solution. Variations in the levels of experience, grades of professionalization and time available to contribute result in a requirement reflection that is strongly driven by personal interests. Rather than directing the decision process towards the user, it seems to be more important to create an open environment where the diverse stakeholders can contribute and exchange information. Such framing can be achieved by switching user representatives in the steering committee, by making the decision process more visible, or by taking a vote on design alternatives.

10.3.2 Toolkits for infrastructuring activities

Continuous forms of infrastructuring need to be supported by tools that are integrated and linked to usage practice [170]. In the co-design study involving users of an online community, a rating module applied on early alpha versions helped to understand user satisfaction. But this rating mechanism only provided a generic perspective on the advantages and disadvantages of the software. The rating module was implemented as a pop-up similar to a scale display shown on the TV screen, because entering text on TV seemed to be too complicated and unusable. It was particularly the developers who requested more contextualized feedback to understand the forum entries. In order to create feedback more flexibly and easily, without switching the context e.g. to an online forum, the concept of a cross platform feedback tool was established (see chapter 7). The concept of the feedback tool enables users to create screenshots from any device and to enrich them with textual and auditory annotations. In its current form of implementation, users can add several items to a report and can upload feedback to a central server, accessible to both researcher and developer. A further interesting improvement is the direct connection of the feedback to a co-design community, e.g. within a forum, such that other users and developers can directly comment on. The tool can also be used for related infrastructuring activities, e.g. by adding pictures and descriptions of non-technical aspects. Within a more general vision, users would not only provide feedback on an isolated product but would also be able to inform the design of an infrastructure mixture that includes a variety of aspects for both technical and non-technical aspects as well.

With the concept of infrastructure probes (see chapter 6), users can document breakdowns and use innovations. The evaluation of that toolkit has shown the advantages that such an integrated feedback mechanism contributes, e.g. by providing in-situ documentation that can be referenced and discussed later on in personal interviews. But the results also showed that the stimulation of continuous feedback requires certain forms of motivation. The design of the probes is one of the most important aspects when mediating the feedback process. The generation and exchange of annotated screenshots should be as easy as possible, supported by interfaces which are easy to access and easy to use. Additionally, the efforts of providing feedback should be supported to certain degree, e.g. by thinking about bonus systems. Another motivation, especially of importance in domestic contexts, is the attractiveness of the probes in stimulating further exploration, e.g. by describing small tasks, or by stimulating feedback in a more playful manner.

The aforementioned toolkits support users in reflecting how technology is adapted in practice and may also help to continuously improve technical systems. An alternative concept is the direct form of adapting an existing infrastructure by the users themselves. Related concepts are referenced in context of research on end user development [159]. Regarding the infrastructuring concept, in-situ design work can be done directly without the additional re-programming of the available software systems. The case studies in this thesis validate the opportunity to use digital pen and paper technology to handle such modifications. By using this technology, users can easily adapt interfaces to their own needs, and can modify various layouts for different services. Instead of having fixed defined interfaces from the technology provider, users can flexibly choose interface elements in different sizes and functionalities. The intuitive handling of pen-based interfaces especially supports non-expert users to become involved in professional domains like service modelling. Complex tasks can be separated into sub-tasks and rearranged in new forms that trigger more complex functionalities. In further work, this concept could be related to different devices and services within the home to provide easy ways of adapting functionalities. Self-designed layouts or best practice layouts could then also be shared with other households to support direct access for more complex tasks and also to recommend services and content.

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