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Proceedings of the 2nd International Workshop on Open Design Spaces (ODS 2010)

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Open Design Spaces – Socially Crafting Interactive Experiences

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Abstract. Engaging end-users and user communities to take an active part in the co-creation, evolution, and appropriation of modern, interactive systems has become an increasingly important issue over the last years. Bringing together existing research and experiences as well as new challenges such as long-term, large-scale, or highly distributed stakeholders has led to the notion of Open Design Spaces (ODS) to frame and reflect current developments of distributed co-design. Several, formerly often separated strands of research covering different aspects of these challenges have emerged and led to a growing community of researchers and practitioners building on concepts such as Participatory Design, Meta-Design, and End-User Development. The 2nd International Workshop on Open Design Spaces (ODS 2010) focused particularly on social aspects and community co-creation in Open Design Spaces.

Preface

Active user communities can have an enormous creative potential for the development of interactive products. This becomes particularly obvious by recent achievements in the areas of digital and social media. Some examples for new forms of design collaboration are websites for customer-company exchange such as *GetSatisfaction* and *RedesignMe* or the appropriation of social networking platforms such as *Facebook* or *MySpace* to support user-designer communities. Examples are also the myriads of *mashups*, *apps*, and *plugins* that have been built by user communities in order to enrich the interactive experience with digital products and that sometimes even become inherent parts of the products themselves.

However, empowering user communities to engage in the development and evolution of interactive products and environments is usually a complex task that requires a deep understanding of the underlying socio-technical processes and interaction principles (Stevens 2009). We developed the notion of *Open Design Spaces* (Budweg et al. 2009) to address this challenge and to frame the growing research in this area.

Open Design Spaces (ODS) are environments for co-creation that encourage a continuous dialog between users and developers with the goal of transforming the traditionally separated spheres of design and use. User communities are regarded as co-designers who carry different interests and cultural backgrounds into the development of interactive products.

The ODS concept is related to Participatory Design (Schuler & Namioka 1993), Meta-Design (Fischer & Scharff 2000), Living Labs (Schaffers et al. 2009) and End-User Development (Mørch et al. 2004), but in particular addresses social aspects of distributed and community-driven co-design in interactive environments. ODS are characterized by transparency, ad-hoc collaboration, self-organization, social feedback, evolving ideas, and evolutionary development (Budweg et al. 2009). The aim of ODS is to foster the generation of novel ideas and the sharing of creative solutions to the benefit of the interactive product, its user community, and perceived experiences, having regard to the fact that participants are usually highly distributed and sometimes even hard to anticipate in advance.

The *2nd International Workshop on Open Design Spaces (ODS 2010)* focused specifically on the social aspects of Open Design Spaces. It addressed concepts and principles for successful co-design in online environments, the activation of large- and small-scale user communities and their integration in distributed design processes. The workshop took place at the *8th ACM Conference on Designing Interactive Systems (DIS 2010)* in Aarhus, Denmark, on 17 August 2010.

This IRSI issue contains the papers of the talks that were given at the workshop. We thank all authors for their contributions and the members of the

program committee – Paloma Díaz, Monica Divitini, Pelle Ehn, Jean-Marie Favre, Gerhard Fischer, Asbjørn Følstad, David Geerts, Effie Lai-Chong Law, Walid Maalej, Jörg Niesenhaus, Wolfgang Prinz, Hans Schaffers, and Alex Voss – for providing their expertise and giving elaborate feedback. We also thank the IRSI editors for giving us the opportunity to publish the workshop proceedings in this issue.

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Challenges of Using Open Online Design Spaces – Case Monimos

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Abstract. Social software makes it possible to involve large user groups in innovation projects. In the Monimos case study an online innovation space was used for designing a social media service for a network of multicultural associations. Immigrant representatives participated in the core design team in regular face to face meetings and workshops. Additionally an online design space was used to make participation in certain design activities open for the public. Although open innovation may result in better solutions, a lot of facilitation is needed in order to integrate online contributions efficiently into the web service development process. In this paper we present the challenges of combining open and restricted design spaces with different participant groups.

Introduction

Social media provides new opportunities for companies and researchers to involve customers and end users in innovation and product development. Online tools seem attractive especially in idea generation and feedback gathering, since a lot of users and customers can be reached easily, quickly and cost-efficiently. Users can be involved as innovators and design partners that are continuously connected with the developers via social software. An open and transparent design process that allows more people to participate with their knowledge and skills may lead to higher quality in design, even if individual participants only make minor contributions (Tapscott &Williams, 2006).

Typical examples of utilizing social media in open innovation relate to idea campaigns or design challenges, in which people submit an idea or design solution once, but do not participate actively in the design process over a longer time period. Even if a feedback and idea forum is constantly open for anyone, users are mainly proposers instead of partners in the new product development process. The company makes the decisions, although user feedback and suggestions are taken into account. On the other hand, there are a lot of examples of participatory design projects in which users participate as design partners and decision makers during the whole process. However, in these cases users, designers and developers normally communicate in closed workspaces either face to face or using software tools. Social software may be used as well, but the workspace is normally restricted for the selected user group and not publicly accessible.

We studied how these two approaches, namely open innovation and participatory design, could be combined by taking the best of both worlds. We designed and developed a multicultural social media service using an online design space which was open for anyone during the whole development process and involved a team of end users in regular face to face design meetings during a period of eight months. The online design space was used by both the "core team" as well as "strangers", who may have contributed only once or continuously during the design process.

While establishing and using the open design space we encountered a lot of difficulties. Total openness and continuous online representation of a design process produce new challenges that are reported in this paper. Based on our experiences, we conclude with suggestions for using online design spaces in user-driven innovation projects.

Background

User-driven innovation

The popular concept of *open innovation* refers to utilizing both internal and external ideas and knowledge in innovation processes (Chesbrough, 2003). This paradigm stresses the company-company relationships as well as technology, knowledge or IPR (intellectual property rights) transfer over the company boundaries, but users are not necessarily involved (Piller & Ihl, 2009). *User-driven innovation* is a more exact form of open innovation that regards potential users as a resource in the innovation process (Holmquist, 2004). In user-driven innovation, a *participatory design* approach can be used, meaning that users are involved as co-designers of the system by means of methods like workshops, scenarios and mock-ups (Schuler & Namioka, 1993, Ehn & Kyng, 1991).

Even in user-driven innovation, the locus of innovation is still usually inside the company that is responsible for the design decisions and implementation of the product or service. Depending on the level of user involvement and role in the innovation process different terms are used:

- *Co-creation*: Interactive value creation with the customers and users starting from the early phase of the innovation process which is still driven by the company (Prahalad & Ramaswamy, 2004; Piller & Ihl 2009)
- *User innovation*: Users are not seen only as consumers or customers but as a significant source of innovation. Users typically innovate at the site of using the product or service. (von Hippel, 1986; von Hippel, 2005) Company's role is to find the so called "lead users" and provide them with toolkits that help users to carry out own design tasks (von Hippel, 2001).
- *Community innovation*: Innovation starts outside companies in distributed and networked user communities (Botero et al. 2009). Company may act as an enabler or facilitator.

Social media as an online design space

Social media, like blogs, wikis and community services, provide a fertile ground for user-driven innovation, since they rely naturally on user participation, content creation and communication. Two different ways to use social media in innovation can be identified: using the power of masses on the web (crowdsourcing) and using online tools as so called open design spaces with users.

Crowdsourcing means outsourcing a part of the innovation or design work to the public - unknown crowd on the internet (Howe, 2006). It has been used both in idea competitions (Leimeister et al., 2009) and in small design tasks - so called micro-tasks (Kittur et al., 2008). The tasks are typically defined by a company and only short time contribution in the early stage of the process is expected from individual users instead of continuous collaboration (Huber et al., 2009).

Social media tools can also be used as *open design spaces* that support users' participation during the whole innovation process. Transparent and community driven design approach was first known from the open source movement but can be applied in other domains as well (Hagen and Robertson, 2009). Despite the name, open design spaces of long-time co-creation projects are often restricted to only a certain group of users. E.g. Hess et al. (2008) formed a remote user parliament that used conference calls and wiki for communicating feedback, problems and suggestions for a new product version. All interested users of the product could apply for membership in user parliament, but after the project started, no new members were admitted to the online forum.

User-driven design of the Monimos service

In our case study a multicultural social media service Monimos[1] was developed in collaboration between the Somus[2] and EPACE[3] projects and the Moniheli network, which is a co-operation network of multicultural associations in the Helsinki region. The aim of the Monimos service is to support immigrants' networking and civic participation both online and offline. Monimos service provides means for associations to raise public or internal discussion, create polls and advertise events. It supports bottom-up civic activity and will eventually be administered by the Moniheli network.

A community-driven participatory design approach was used, meaning that the idea and goals for the service were created together with the user community and the community also had an active role in design and decision making throughout the development process. The potential end users were contacted via Moniheli.

The core design team consisted of ten immigrants, two representatives of Moniheli, a web developer, a designer, and six researchers from different areas (social media, civic participation, immigrant media, participatory design and software business). The core team held monthly design workshops, in addition to which the researchers had their weekly meetings.

Since the goal of the Monimos project was to create a social media service that supports civic participation, it was natural to use social media to involve users in the design process, as well. We used an online space which was open for anyone who wanted to participate in developing social media services for immigrants.

Owela as an online design space

The Monimos development process utilized a design space in Owela (Open Web Lab)[4] that is a blog-based online space for user-driven innovation (Näkki & Virtanen, 2008). Owela supports writing ideas or suggestions, commenting, and voting between different suggestions. Ideas are typically in textual form, but images, videos or slideshows can be added to the posts as in any blog system.

In the Monimos case, content and commenting in the online design space was open for everyone, but in order to create an own profile and take part in voting, users needed to register in the website. Sixty users signed up, forty of which did not belong to the core design team and thus participated only via online design space. People were invited to the the online space by sending email or sharing the address on the web, e.g. on a discussion forum for immigrants in Finland. The

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1 http://www.monimos.fi

2 http://somus.vtt.fi

3 http://www.kansanvalta.fi/en/Etusivu/Tutkimusjakehitys/EPACE

4 http://owela.vtt.fi

participants included members of the Moniheli network, as well as individuals who had no connection to any multicultural associations. The most active users of the Owela space were the core team members who used the online tool for communication between the workshops as a tool to supplement email.

Initial ideas for the social media service were collected in a design workshop with representatives of public sector, immigrants and media. Altogehter eighteen ideas were then presented publicly in the Owela space, in two languages (Finnish and English). Both registered and non-registered users could comment and rate the ideas as well as add their own ideas for the immigrants' social media services. These comments were used as a basis for the service concept development..

Later on,, Owela was also used to create a wish list of features and for prioritization of the features by voting. Comments and voting were also utilized for decision-making about the structure, layout and name of the service. Open discussion was used especially to clarify the relation of the Monimos service and other websites of the associations that were involved. In the final phase, comments regarding specific questions, e.g. the display and publicity of user profile information were requested, but very little discussion took place anymore. Table I displays the amount of posted topics, comments and votes (if available in that type of posts). The original topics were written by researchers, except in the discussion category. Comments and votes were given both by users and researchers.

Category Number of:	Ideas	Features	Layout	Name	Discussio n	Profile questions
Topics	18	33	3	26	11	6
Comments	43	85	5	90	32	2
Votes		370	4	41		

Table I. Amount of topics, comments and votes in different categories.

Challenges of using the Owela online design space

In the beginning of the design process there was great interest in having the design and development process be totally public, transparent and open for anyone. However, it turned out to be challenging to update the public design space in such a way that newcomers would always get the point easily and that the contributions of random users would support the design process. It also appeared to be challenging to use the same open design space both with the unknown public and with the core team that had a lot better understanding of the state of the process and aims of the service based on the face to face meetings and workshops.

Type of tasks. The advantage of crowdsourcing is that when many people collaborate, small individual contributions make the big picture. In this case study the online contributions by were mostly useful in relatively simple tasks. The most discussed topics were the single features and the name of the service. Layout or user interface issues related to user profile produced only few comments.

Structure and schedule. When the whole design process is open for everyone all the time, there is a need for very clear goal setting and structured process with well-defined tasks in which newcomers can easily participate without needing to understand the whole development process. In our case it was difficult to communicate the goal of the process in the beginning, when there was no idea about the service that was actually going to be innovated and developed together with the users. Some users felt frustrated, because they could not see the concrete goal or outcome of the process.

Updates. Continuous documentation of the state of the process requires a lot of work from the facilitator or moderator of the design process. However, it can also be seen as an advantage, since thorough documentation makes participation easier also to those core team members who could not be present in all the workshops.

Transparency. It was necessary to continuously balance what to publish online and which information should be kept within the core team. Eventually, quite a lot of the essential communication was done via email among the core team, since the open online space did not feel appropriate for all issues that were relevant only for the core team. One clear missing feature in Owela discussions was that users did not get any automatic email notifications of new discussions and comments, and therefore the core team preferred sending email in important and urgent matters. The online participants who did not participate in the core team and meet face to face were thus left out of the design process. Of course, not all the details are relevant for those who only randomly comment some questions online, but they should still receive enough information to be able to participate equally.

Clarity of expression. The formulation of ideas and questions needs a lot of consideration, since the participants can be basically whoever with different backgrounds and in this case even with different languages and cultures. Abstract concepts and ideas in the early phases are understood in different ways, especially when people are introduced to them only in written form. Therefore visualizations of the concept would be useful already in the very early phases of the process. However, they may also lead to wrong conceptions, if participants get stuck with the early concept pictures.

Moderation. In the case study no inappropriate comments were posted in Owela, although commenting did not require registration. However, there were some technical problems with the spam filters, and the moderator needed to clean up the spam comments sometimes. A bigger challenge was to consider, if very negative comments of some users to others' ideas should have been moderated to promote more positive and inspirational environment for innovation. On the other hand, all participants should have the right to express their opinion in their own way.

Beta development. The development version of the Monimos service was constantly online on the web. However, the address of the website was given only to the core team and was not published openly in the Owela space. We did not want to show the early development versions of the service to "strangers" to avoid giving them a negative first impression of the service that was still under development. Therefore, the continuous testing and evaluation was done only by the core team, and the open design space was not used as such anymore. Instead, chat sessions were organized for the core team. Everyone could test the Monimos service at the same time and report findings, ask questions and suggest improvements in a chat. The developer and researchers also participated in the caht session, so that minor modifications could be implemented and deployed to the service right away. Although the Owela space was not updated in this phase anymore, some users still commented older ideas that did not have any relevance for the development.

Conclusions

We used Owela open online design space for the development of a social media service for multicultural associations. The open design space proved to be beneficial in the clearer phases of the process, especially for comments on concept ideas and features, as well as for voting between different suggestions. However, the vision of the service and common goals are abstract and difficult to crystallize using only text-based online communication. Face to face meetings with the core design team proved to be important for creating a common language and shared understanding of the service especially in this case with multicultural participants.

Facilitation of a public design space requires careful consideration and a lot of resources. The information must be continuously up to date and clearly expressed to make it understandable for participants with various backgrounds. Open innovation does not just happen by itself: Someone needs to develop the concepts and do the "hard" work between the ideation and evaluation parts that are inspiring for the users. Being part of an open process requires openness from the participants, too. Especially in the beginning, they must be able to tolerate the blurry goals that will be refined and more clearly formulated throughout the process.

Based on our experiences, we suggest that an open online design space should not be used as an only communication tool among the design team, but as a complement to the team work in certain moderately simple design tasks. It could be most beneficial in the starting phase, when a lot of ideas are sought after. Later on, clear questions or tasks for the open public should be defined after each design team meeting. The online comments and votes could then be taken into consideration in the next design phase. The tasks must be scheduled clearly so that online contributors know, if their comments can still be taken into account in the development.

Acknowledgments

Monimos case study has been done in the Somus (Social media for citizens and public sector collaboration) project, in collaboration with the EPACE (Exchanging good practices for the promotion of an active citizenship in the EU) project and Moniheli network. Somus has been funded by the Academy of Finland, and EPACE by the Fundamental Rights and Citizenship Programme of the European Commission. We thank the funders, researchers and participants in the case study.

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Process Tools for Interaction Design

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Abstract. In this work we describe tools that can be used to extend the *User-Centered Design* (UCD) process in its individual phases, such as user research and analysis, ideation, prototyping and usability testing. Doing so can potentially result in the three key advantages of a) involving a broader audience in the design process, b) simplifying multidisciplinary team communication, and c) providing tools that ease and speed up the development process. In this paper we are providing suggestions how such extensions, in the form of toolkits, might look.

Introduction

User-centered design and/or interaction design techniques are considered as an essential task when designing electronic products or interactive systems a stated by Buchenau et al. (2000), Lidwell (2003), Maguire (2001) and Saffer (2006). Interdisciplinary work-process models, as presented by Borchers (2001), that are not entirely engineering driven, have become more relevant in order meet users' expectations and needs. To accomplish this task and achieve a good outcome, expertise knowledge about the individual phases of UCD (see Figure 1) and techniques needs to be incorporated. However, not everyone possesses the appropriate skill-set applying UCD in their work-processes. In order to lower the participation barrier for a wider audience, we propose an approach where different process tools and methods are applied, offering possible extensions in UCD that make participation and execution easier for developers of interactive systems, unfamiliar with interaction design practices and principles. We introduce possible extensions in forms of toolkits to be applied within the user centered design process. These toolkits are indented to possess an easy and cheap reproducibility. Doing so we propose an improved UCD model that itself potentially provides a high applicability (see Figure 3).

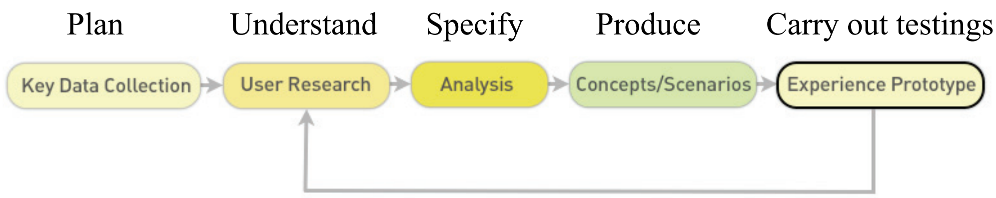

Figure 1. The UCD Process with its individual phases.

Related work

Low fidelity prototyping tools as described by Burns et al. (1994) or Hartman et al. (2008) are an integral element within interaction design practice. Buxton et al. (2007) and Tohidi et al. (2006) constantly proposed a *culture of sketching* thus, getting the design right. Svanæs et al. (2004) described a good example in their work of how end users can enrich and participate in the design process. In their workshop series, they provided different tools that empowered participants designing a mobile interactive system. Their, and other approaches, as exemplified by Snyder (2003) or Rudd et al. (1996), helped users to join the user centered design process by providing them with methods that incorporated familiar low-fidelity tools such as scissors, pen, paper, and glue. However developers are sometimes facing problems applying these methods to improve the design of a system as concluded by Greenberg et al. (2008). In contradiction to them our approach is oriented towards toolkits that provide possible starting points via pre-made elements and instructions. IDEOs (2003) method cards have been used in workshop sessions to develop complex scenarios for international clients, many designers and researchers have investigated how these tools can be developed further: Halskov et al. (2006) presented an extension of a scenario based process tool by providing inspiration cards that were related to a place or a new technology, helping designers to rapidly generate their own ideas. Wahid et al. (2009) exemplified a method that is intended to speed up the process of creating a design scenario using both high and low fidelities; their system exists as physical paper artifacts, whereas a complete digital version is online and open for extension by users. While both previously mentioned tools are intended to help designers communicating within the team, we are focusing on frameworks that would enhance communication between developers and end-users.

For a more physical fidelity experience, prototyping platforms such as Arduino (2007) or visual programming environments as presented by Koenig et al. (2010)

enable members of a wider user group to create their own experience prototypes, as stated in the work of Klemmer (2006) while the framework simplifies communication between sensors and multimedia computers, lowering the level of expertise knowledge previously required. In addition to them we want to establish tools that are also expandable by end-users, empowering them to grasp a complex, technological relationship more easily.

Tools for interaction design

In our research project, we are currently investigating exemplary tools that complement and extend each individual phase of the UCD process on both high and low fidelities (see Figure 2). In the following section, we will provide an overview from three of these tools, still in an explorative state.

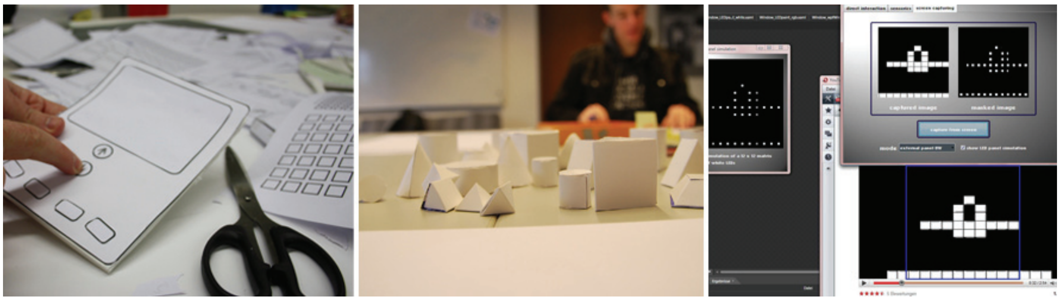

Figure 2. (From left) Interaction design tools which are currently explored: (a) Sketching with Objects (artifact from a brainstorming session) (b) Paperbox 3D (ideation prototyping for a TUI) (c) Building in a Box (screenshot from the capture tool).

User research phase: sketching with objects

Sketching with Objects is a low-fidelity toolkit consisting of two-dimensional (2D) interface elements, for example symbols for screens, icons for various forms of interactions such as *Radio Frequency Identification Devices* (RFID), smart-cards, or Bluetooth. Furthermore, the kit contains various graphical elements for buttons and textures. In the initial project brainstorming, the toolkit offers a range of elements that participants can cut out and glue onto Styrofoam elements, creating early mockups of prototypes from initial ideas. These artifacts can be used during user research sessions, simplifying communication during interviews, as explaining technologically complex concepts to end users can be a time-consuming task. Furthermore, the generated artifacts can serve to focus attention on possible opportunity/solution spaces, together with questionnaires in the first informal interviews with end users regarding their needs and desires. *Playful mobile interactions in an art history context* is an exemplary project where this tool is currently explored further, developing a new guide for an art museum, thus providing one possible process extension (see Figure 3).

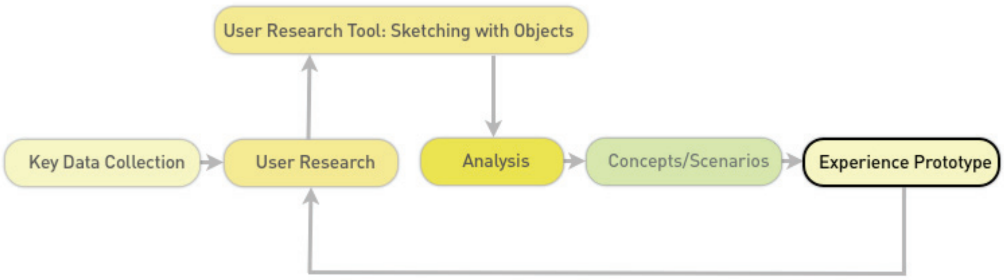

Figure 3. An UCD process model including the tool Sketching with Objects.

Concept phase: paperbox

Paperbox is a tool that is intended to be used when designing tangible user interfaces (TUIs) on interactive surfaces. Providing three-dimensional (3D) primitive models based on the theory of object recognition, a variety of geometrical icons (Geons) made out of white cardboard in different sizes serve as mediators between developers and end-users, intended simplifying communication (see Figure 2, middle). These shapes provide alternative stimuli when pre-testing different applications in this domain as well as the affordances implied by a TUI. The toolkit can be used in initial usability tests on pure low-fidelity using paper or hybrid interaction forms. End users are invited to suggest their own ideas and to express physical needs by defining appropriate affordances for mixed digital/physical interaction forms.

Experience prototyping phase: building in a box

Building in a Box is one example of how end users can easily bring in their own preferences in terms of digital content. This experience prototype consists of a mobile LED panel that can potentially be used for early content explorations intended to be later implementation on a multimedia facade. By equipping the panel with hardware and software components, for example an application that allows end users or potential clients to capture a region on their computer screen such as YouTube videos (see Figure 2, right), it is possible to translate the content to a mockup of a multimedia facade. By doing this, experience prototyping is more accessible to end-users, resulting in own ideas for content being brought into the project.

Discussion

Regarding the applicability of these tools there is the need to consider the development of a classification system. We are only providing some examples for very specialized use-cases, hence we will be only able to deliver evidence on the beneficial aspects of UCD extensions in these cases. However if development teams are working in different HCI domains, a structured framework and guidelines can possibly help re-use elements of our implementations.

Conclusion and future work

We have described three possible extensions for UCD in the form of toolkits. Considering the fact that the described work-process tools have not been fully explored and evaluated yet and are still in different stages of development our assumptions might not be verified. In the next month, we will develop the mentioned tools further and conduct user studies to elicit more insights into whether this path is feasible. Another aspect of the project that remains undefined is the question of which measurement techniques should be applied for analysis. Criteria can be based on cognitive psychology, educational psychology that focuses on the creative outcome of the process, aesthetically appealing design, or usability aspects.

Further, a standardized, digital version of these tools, incorporating a high reproducibility, can be a door-opener to communities, as extensions of these tools through a growing user group can be beneficial for the success of such systems.

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SourceBinder: Community-based Visual and Physical Prototyping

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Abstract. Physical interfaces broaden the entrance into the virtual world through sensors and actuators in our surrounding. Prototyping these interfaces demands expertise in hardware and software development – skills that are rarely found in end users, hobbyists or designers. If those users want to build a rapid prototype for a quick exploration of an idea, they are often troubled with learning the necessary programming and hardware engineering skills. The entry barriers for these target users can be lowered by providing suitable hardware and software toolkits. SourceBinder is a web-based visual programming tool that enables users to create projects and share them in a community. Users can test and adapt existing projects and even become developers by creating new nodes that can be used by the community. We want to present our extensions of SourceBinder which enables hardware to be connected to the visual programming environment, and show some example projects that can be realized in such a setting.

Problem statement & motivation

> In biological systems, there is a tendency for specialised organisms to win out over generalised ones. My argument is that the evolution of technology will likely be no different. Rather than *converging* towards ever more complex multifunction tools, my claim is that going forward we must *diverge* towards a set of simpler more specialised tools. (Buxton, 2001)

Although Buxton's claim about the need for more specialized devices is highly controversial, actively promoted research domains like tangible or ambient interfaces and successes in industry (e.g Nintendo Wii input devices, Guitar hero for game consoles, the customizable Nabaztag rabbit[1]) show the interest of users in easy-to-use one-purpose tools. Tangible interfaces allow us to experience and manipulate digital information with our hands and sense of touch through specialized devices (Ishii & Ullmer, 1997) (Holmquist, Schmidt, & Ullmer, 2004). Ambient interfaces present information in the periphery of our perception through everyday artifacts in our daily life (Weiser & Brown, 1996) (Gross, 2003). As we are moving from a GUI-based interaction with the computer towards a more natural interaction that involves everyday objects, our movement, gestures and senses, combining suitable input and output modalities without converging too much functionality in one interface is key to success and adoption of an interface.

Giving end users the ability to participate actively in the development of applications proved to be successful for the Web 2.0, where users are moving from a consumer to a producer role (Fischer, 2009). For physical interfaces some people also try to refit them for their needs as can be seen in MAKE magazine and various other DIY-magazines and workshops (e.g. dorkbot[2], Makerfaire[3]). A study carried out by Hartmann et al. showed that product designers as well as hobbyists developed different strategies to *glue* together existing hardware and software components to create *ubicomp mash-ups* (Hartmann, Doorley, & Klemmer, 2008). Although interfaces to hardware and software are often well defined, programming effort is mostly inevitable in order to glue together components. Some users apparently are motivated to learn the needed skills to adjust physical interfaces and create code to connect software and hardware components, others do not feel skilled and proficient enough to hack and mash assembled devices and program script code. How can we make use of this continuum of participation? How does a prototyping environment for creating physical interfaces need to be designed in order to integrate users at different levels of participation?

After presenting recent advances in hardware and software prototyping toolkits for creating physical interfaces, we introduce SourceBinder, a web application that enables users to visually bind together hardware and software components and let them actively participate in the development and adaption of new components. After describing the general concept and our extensions for using the Arduino hardware, a short example illustrates the usage of SourceBinder and Arduino. The strategies we considered for the community-based development of SourceBinder are summarized and first observations and a short evaluation is explained.

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[1] http://www.nabaztag.com

[2] http://www.dorkbot.org/

[3] http://makerfaire.com/

Related work

A physical interface consists both of several hardware and software components that need to be connected/bound/glued together. After presenting related work in these separate domains, we want to introduce toolkits that already try to combine hardware and software prototyping.

Sketching in hardware for non-technical users like artists, hobbyists or even children is getting easier with toolkits like Phidgets (Greenberg & Fitchett, 2001), Smart Its (Gellersen, Kortuem, Schmidt, & Beigl, 2004), Calder Toolkit (Lee et al., 2004), LittleBits[4], Lego Mindstorms[5], Arduino[6], Electronic Bricks[7] and many more (see (Cottam & Wray, 2009) or (Moussette, 2007) for an overview). Assembling hardware becomes nearly as simple as plug and play. Arduino for example is used in classrooms to teach basic skills in electronic and to lower the barrier for tinkering with hardware, but also academia is using Arduino for building interface mockups. The active user community around Arduino has already created a lot of additional tutorials and software plugins which make the toolkit even mightier. The great interest of non-expert users in implementing their own hardware prototype is demonstrated heavily on Flickr and YouTube with a total of more than 50'000 uploads tagged with "Arduino". Also conferences like "Sketching in Hardware"[8] and workshops like "DIY for CHI: methods, communities, and values of reuse and customization" (Buechley, Rosner, Paulos, & Williams, 2009) promote advances in this area.

Lowering the barriers for programming software is also an active research domain. Possibilities are manifold, e.g. visual programming, tangible programming or animation software (Kahn, 1996). Visual programming hides the underlying complex code with graphical symbols that can be reused and combined with other blocks. Alice is used to introduce students to programming and lets them build their own 3D animations (Cooper, Dann, & Pausch, 2000). Agentsheets lets users build their own simulations in their domain of interest (Repenning, 1993). Microsoft's Kodu[9] enables children to create their own game by defining simple rules with input- and output-events, that can be shared in the XBox community. Max/MSP[10] is a commercially sold product that allows music artists to program audio signal processing code with graphical objects.

4 http://littlebits.cc

5 http://mindstorms.lego.com

6 http://www.arduino.cc/

7 http://www.seeedstudio.com/depot/electronic-brick-c-48.html

8 http://sketching10.com/

9 http://research.microsoft.com/en-us/projects/kodu/

10 http://cycling74.com/products/maxmspjitter/

Visually programming software and hardware is more difficult, since the physical hardware prototype has to be connected to the software workbench and changes in one part have to be reflected to the other. d.Tools allows prototyping with the Arduino hardware by letting users model the interface and state transitions visually (Hartmann et al., 2006). It also integrates a test and analysis mode for inspection of logged user tests. Scratch is originally developed for children to create multimedia applications (Resnick et al., 2009), but was already extended by an active user to allow Arduino to communicate with Scratch[11]. Other examples are the Lego Mindstorms NXT software (based on LabView), Fischertechnik's ROBO PRO[12] or Physical Etoys[13]. While these environments allow end-users with little programming knowledge to create complex physical interfaces, and people with more knowledge can often extend them with little scripts, these extensions mostly stay in the hands of the experienced users and the community cannot profit from them.

With SourceBinder we want to broaden the ecology of participation in an online visual programming environment, where components can be created, shared, rated and adapted in the community.

SourceBinder

SourceBinder[14] is a web-based tool in Beta status for visually creating Flash applications by binding nodes together (see Figure 1) that enables users to become active developers. *Nodes*, the building blocks of SourceBinder are regular ActionScript classes. They can be classes providing simple functionality but they also can be complex components as well. SourceBinder comes with most of the intern Flash functions built in as regular nodes, and some elements of favorite open source packages like Papervision 3D library, the WOW physics library, WiiFlash package to handle WiiMote, the as3glue package for dealing with physical computing and nodes providing common webservices like YouTube, Yahoo, and Google Maps. To allow engagement of users on different levels of complexity (Fischer, 2009) a node has three states, each allowing more possibilities to change the behavior. 1) In its basic state a node is just depicted by a symbol and allows connecting inputs and outputs of the node. 2) In the second state, the public attributes of the node become visible and can be changed directly or through binding it to another node (see Figure 2). 3) The third state shows the source code that can be changed and compiled. Thus a node can be adapted according to the user's knowledge level, either by just binding it to other nodes,

[11] http://scratchconnections.wik.is/index.php?title=User:Chalkmarrow/Catenary

[12] http://www.fischertechnik.com

[13] http://tecnodacta.com.ar/gira/projects/physical-etoys/

[14] http://sourcebinder.org/

by further influencing attributes or by directly changing the code. Therefore SourceBinder can be seen as a repository for community-built software components (Wulf, Pipek, & Won, 2008) with a graphical interface to combine, modify and extend them. Nodes can be combined to a network of nodes which produces a program which is called a *composition* (see Figure 1).

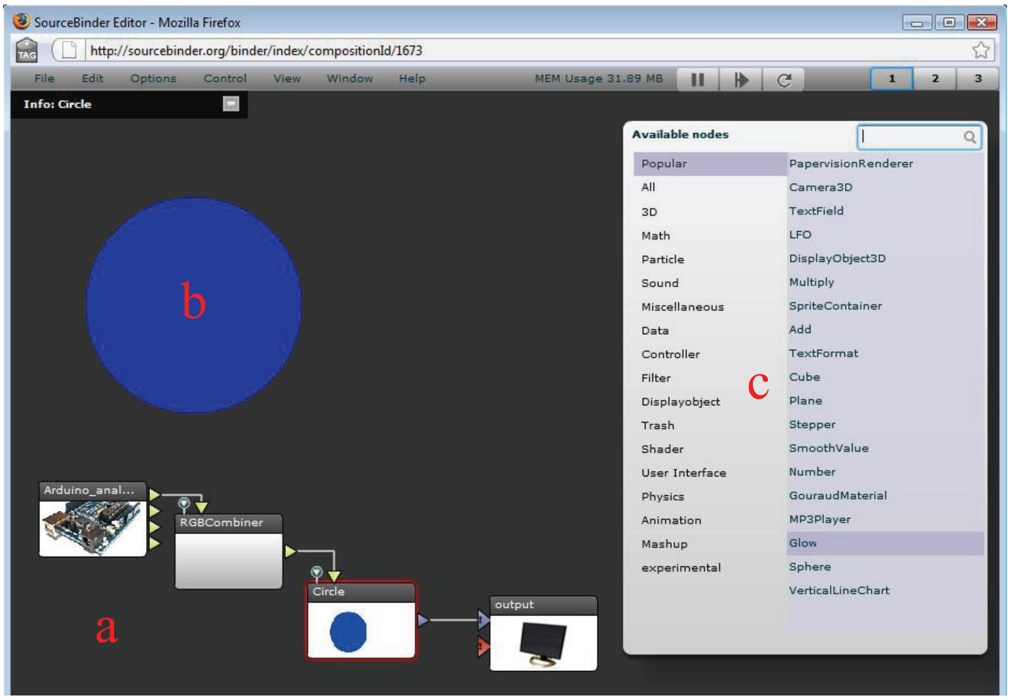

Figure 1: Composition interface: (a) Nodes are bound together, (b) a preview of the composition is shown in the background, (c) new nodes can be added to the composition via a browsable menu. In this example an analog sensor controls the blue pigment content of the circle

Figure 2: Attribute inspector of one node (second state of a node). (a) Attributes can be modified directly, (b) be bound to the output of another node or (c) be published to the global attributes panel for direct modification within the whole composition. (d) The source editor (third state of a node) is accessible at the bottom of the node.

Arduino extension

In order to test the extensibility of SourceBinder and building a platform for physical prototyping, we extended SourceBinder with Arduino nodes (see Figure 3). An Arduino Duemilanove board consists of a microcontroller and several pins for analog and digital reading and writing of attached sensors and actuators. We chose to implement one node for each functionality (analog r/w, digital r/w) to not overburden one node. The first is for analog reading of signals (e.g. sensors for light, temperature, pressure). If a sensor is attached to one of the analog pins, its value can be read by binding one of the outgoing arrows that correspond to the pin to another node. The second one is for digital writing (e.g. LEDs) and receives values over the incoming arrows that represent the pins on the Arduino board. The third experimental node is for analog writing (e.g. motors, RGB LEDs) and receives values from 0 to 1023 over the incoming arrows.

Figure 3: From left to right: (1) node for retrieving analog sensor input from the Arduino Duemilanove board, (2) node for writing digital values, (3) experimental node for writing analog values

The basic procedure for connecting an Arduino Duemilanove board is as follows: In order to let web-based Flash applications communicate with your computer a special policy file has to be adapted and run. This complication is due to the browser based design of SourceBinder and would not be needed if it was a standalone application. In addition, the Arduino needs to have Firmata (a special firmware) (Steiner, 2009) uploaded in order to communicate with SourceBinder. This connection process is not the easiest for novice users and needs to be further simplified.

Physical mood interface: demonstrating SourceBinder in use

In order to show the basic process for creating a project in SourceBinder, we want to illustrate the creation process of AngryBall (see Figure 5). It lets users share their angry emotions via Twitter by punching, hitting or pressing a rubber ball. This project was composed by a student who implemented a node for sending Twitter messages. For clarity, we only explain the binding process of the finished nodes not the implementation details.

Jan comes back home after an exam that didn't work out well. He wants to inform his Twitter friends about his feelings but is way too stressed and angry at the moment. Punching a ball to let loose his emotions he thinks of a new kind of interface where he can send Twitter messages simply by squeezing his "angry ball". A small pressure sensor fits perfectly into the ball and he connects the pressure sensor to his Arduino Duemilanove board. He opens up SourceBinder and drags the *arduino_analog_read node* on the composition area (see Figure 4). This node has several outgoing arrows that transport analog values (0-1023), each symbolizing one analog pin on the Arduino board. He connects one outgoing arrow of the node to the *GreaterThan node*. If the pressure sensor reaches a certain value it should trigger the Twitter message. He modifies the value of the compare node in the attribute inspector to 500 and connects its output to the SendTwitterMessage node. He adjusts the attributes of this node to his username, password and the message he wants to send ("I am sooo angry"). As soon as the Arduino node receives a value greater than 500 from the pressure sensor, the comparison node evaluates the result as true and triggers the SendTwitterMessage node that directly posts the message on the Twitter website.

Figure 4: Composition of the AngryBall project

Further projects with Arduino

Several projects have been created at our lab using SourceBinder and its Arduino extensions. Since new web services needed to be integrated for these projects (e.g. sending a Twitter message, opening a Skype message window) new nodes had to be created with the source editor.

The *Weather Station* retrieves information from the Yahoo Weather Channel and presents this information in an ambient interface prototype made of cardboard (see Figure 5). It uses the *Yahoo Weather Channel node* that retrieves weather information to a given location code. The location code is inserted in the attribute viewer of the *Yahoo Weather Channel node* and returns the temperature, a condition text (e.g. rainy, stormy etc.) and a title. The condition text is then evaluated with the c*ontains node*, if it matches a specified text (e.g. rain). If the weather forecast contains the word rain, the Boolean value "true" is send to one input of the *arduino_digital_write node*. This node has one entry arrow for each of the analog pins on the Arduino Duemilanove board. In our case, three LEDs for each weather condition are connected to the analog pins that reside in a cardbox. A LED is activated as soon as the according weather condition is evaluated positively.

In *FriendWatcher* little dolls represent friends in Skype[15]. Their noses display presence information and are shining green as soon as the person is online. If the doll is pressed, a conversation is started immediately. This composition contains two Arduino nodes. One for activating the LED (writing a digital value) and one for reading values from the pressure sensor (reading of analog values). In this case a student built a *Skype status node* that returns a boolean value if a specified user is online. This node is connected to the *arduino_digital_write node* to activate the LED. The other node is the *FriendsWatcher node* that opens a Skype message box when it receives input. This node is connected to the *arduino_analog_read node* and is activated as soon as the pressure sensor is pressed.

All of the mentioned projects use web services to retrieve or manipulate digital information in the World Wide Web. Besides these also other projects are possible, e.g. to manipulate visualizations or audio with physical handles.

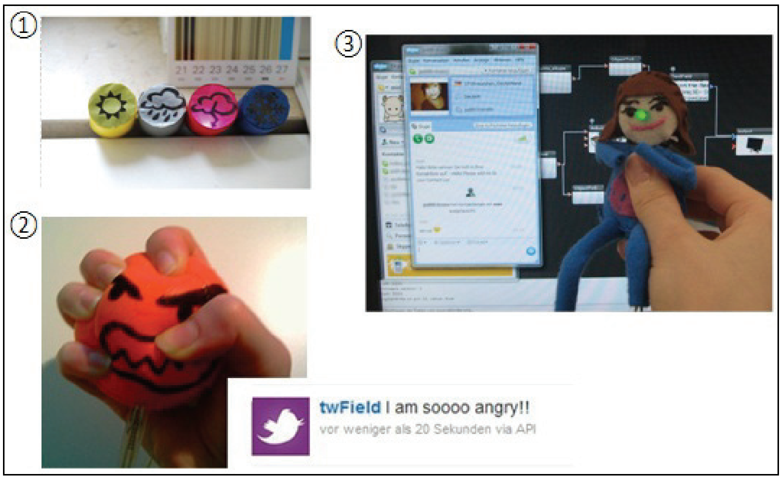

Figure 5: Exemplary Projects: 1) Weather Station 2) AngryBall 3) FriendWatcher

Community features

SourceBinder is thought of as a prototyping platform that evolves with the help of an active community. Therefore strategies for building active and engaged online communities are implemented as follows:

Seeding, Evolutionary Growth and Reseeding (Fischer, 1996)*:* An active community has to be provided with *seeds* (artifacts that engage people in using the application and allow for modification and extension by the community). These seeds serve as a starting point for the evolutionary growth phase where users can extend and modify the current version. The available nodes can serve as *seeds* that allow users to create first compositions. As our first exemplary projects

[15] Skype, an instant messaging and video conferencing service, http://www.skype.com

showed these nodes are sufficient for projects that base on current compositions, but not every imagined project could be created with only using existing nodes. The evolutionary grow phase will show if enough active users with programming skills are motivated to contribute nodes to the community and enriching the library of available nodes.

Clear Authorship and Use License Attribution Systems (Monge, Ovelar, & Azpeitia, 2008): Each node only has one author. The author can determine if he wants his node to be either *private* or *public*. Thus users can create first test nodes in a private environment and decide later to contribute it to the community. If the status of one node is set to public, it is immediately visible in the node library of the other users. Others are now free to use it in their compositions. If they want to modify the source code they can *fork* it (build a copy of it) and customize it in any way they want and now possess authorship over this new node. This can result in a nice iteration, where an idea evolves through the help of other users.

Rapid Content Creation Systems (Monge, Ovelar, & Azpeitia, 2008): To encourage and engage new users SourceBinder offers "Getting Started" compositions to learn the basics about "binding". Recent, popular and featured compositions are presented on the website to get inspired by other projects. Projects can be opened, edited and saved as own compositions. Users can also join a interest group to discuss, share and collaboratively tailor nodes for a specific application area. These groups can also help interested beginners in getting into the details of SourceBinder and creating own nodes.

Reputation Systems for Contents (Monge, Ovelar, & Azpeitia, 2008): To motivate users and integrate feedback mechanisms, a user can see how many views and comments he got from other users (see Figure 6) and can in turn vote for his most loved projects. *Binderpoints* give a user feedback about his binding activity.

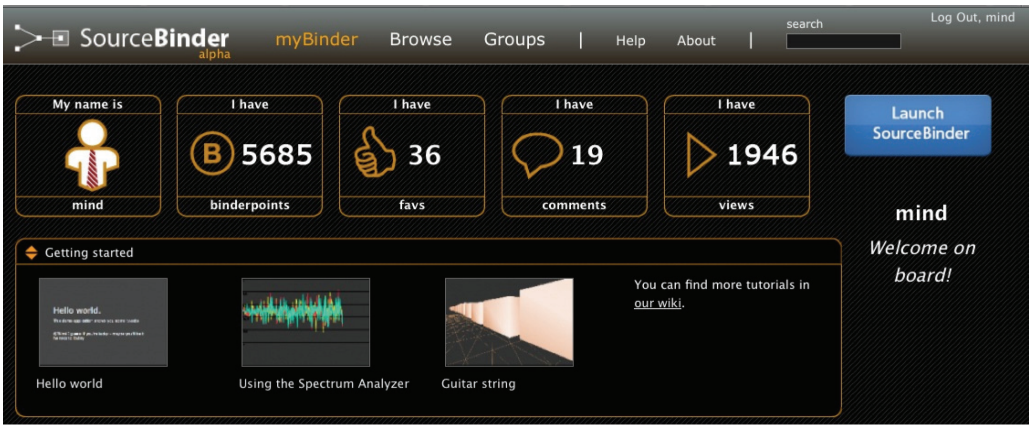

Figure 6: Personal view of one user with feedback mechanisms (binderpoints, favorites, comments, views)

In summary, SourceBinder allows users to engage on different participation levels. Users can either only browse existing projects, they can slightly modify them or build new compositions with available nodes. They can program their own private nodes and compositions, but they can also contribute them to the community and get actively involved in an interest group.

Evaluation

Before opening SourceBinder to the broad public, community-specific pitfalls in the current design have to be identified. We chose to assess SourceBinder with the cognitive dimensions framework for visual programming environments (Green & Petre, 1996), because it allows a broad-brush evaluation with a framework for the most important usability flaws to consider for visual programming. We want to discuss two that are especially critical in community-based development:

Secondary notation includes techniques that convey extra meaning to the reader, e.g. comments, colors, layout. In a community it is very critical to have a precise description of components and whole applications. Users need to have the possibility to annotate their own projects for their own use but also for other users to understand the composition and single nodes. SourceBinder offers the possibility to add descriptions to a node and comment whole projects. What is missing is a commenting function in the projects to annotate groups of nodes and connections between nodes, otherwise projects cannot be adapted easily. Also users should be able to tag nodes to gain more metadata about the node repository (Monge, Ovelar, & Azpeitia, 2008) and allow additional ways to search the node library instead of the proposed categories.

Consistency is another major problem in community-based development. As soon as users start developing their own nodes, they are determining the name, the public visible attributes and the underlying functionality. Some nodes may contain only one single functionality; others may contain a small composition in itself. Nodes can be created that have slightly the same functionality and are also named somehow similar (e.g. three different nodes for sinus calculation: sin, Sin, sinnn). This also affects the findability of nodes: If nodes are not named properly or contain too much invisible functionality, other users cannot adapt that node and will create their own nodes. This can lead to a vast amount of nodes that have slightly similar function. With a growing node set it will be problematic to stay consistent. Possible solutions can be clear guidelines for naming conventions and structure of a node or an approval process of new nodes before making them public. Rating functions could be integrated into the decision by relying on the most appreciated nodes. Active users could be assigned an administrator status to check new nodes for their consistency.

Further usability issues were found during a student's project with SourceBinder and concern the extension of the visual programming environment with hardware. An urging problem is that it is often difficult for non-experts to *connect the hardware* to the software workbench. In this case they have to load firmware on the microcontroller, enable security settings and start a proxy - a task that frightens novice users and might even scare them away. Another problem is that *changes in the hardware are not clearly visible* in the software environment. Although text nodes can be bound to the output of the Arduino node to visualize values, changes would be better visualized automatically in the preview area of the composition.

In near future we want to further heuristically evaluate SourceBinder and afterwards test it with students in a one week workshop to find out about usability issues concerning the visual programming part. As soon as SourceBinder is opened to the public we will analyze the phase of evolutionary growth, e.g. user commitment (roles, usage behavior etc.), quality and the overall structure of created components. This will be achieved with observations and interviews with active users. The insights gained from these observations will then affect the reseeding phase.

Conclusions & future work

Our initial evaluation and explorations of example projects with SourceBinder for visually programming physical prototypes assured us in further investigating its potential benefits. Non experienced people in hardware or software engineering are enabled to "bind" together application logic for creating experience prototypes. They can rebuild projects of other users and can contribute to the mightiness of the toolkit by composing new nodes. Thus SourceBinder can serve as a repository for user generated components. Problems with a community-based component repository development (e.g. consistency of developed nodes) need to be carefully watched in the initial phase after public release of SourceBinder. As SourceBinder is not public yet, we are still able to enrich the seeds sawn for new users, thus we want to discuss possible evaluation and seeding strategies for the community development of SourceBinder at the "Open Design Spaces" workshop.

Future work will include better presentation possibilities of physical prototypes in SourceBinder. Besides the textual description, pictures or videos of the prototype in action need to be supplied. The hardware setup with sensors, resistors etc. needs to be accessible in order for others to rebuild it. Fritzing lets users graphically model a microcontroller like Arduino that is connected to sensors and actuators via a breadboard (Knörig, Wettach, & Cohen, 2009). An integration of Fritzing with its visualization of the involved hardware could greatly benefit the shareability of projects.

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Open Innovation Applied to Smart Metering: a Case-Study into Socio-Cultural Aspects

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Abstract. To date smart meters are not fully implemented in European households to improve energy efficiency. This paper describes a case study on smart metering, carried out within an EU funded project for the design of a novel research infrastructure called Living Lab project, to study the interactions of users with and stimulate the adoption of, sustainable, smart and healthy innovations around the home. To generate ideas that overcome obstacles defined for the implementation of smart metering and that are responsive to socio-cultural aspects influencing acceptance, similar open innovation sessions were arranged in three European countries: Switzerland, the Netherlands and Spain. Furthermore, on a methodological level, the suitability of the sessions for the Living Lab project has been evaluated. Results show that the innovations resulting from the three sessions departed from a common view to engage people in their energy uptake: developing attractive, tangible devices or services, which should be further specified for various groups of people within society requiring different approaches in terms of physical appearance, but also through different ways of social networking. The methods applied in the sessions provided to be a useful method for gathering opinions and actively involving experts and companies in a short period of time, but there were difficulties in both preparation and follow up of the similar sessions.

Introduction

Rising energy costs, growing user demand for environmentally friendly goods, climate change as well as ambitious targets to cut greenhouse gas emissions from European governments lead to the necessity to reduce energy consumption and changes in energy behaviour. This could be achieved by governmental incentives, which are executed by means of technology, for instance power saving lamps and special shower heads that reduce the flow of water.

However, various studies have shown that a purely technological approach to reduce energy consumption often leads to disappointing results, due to unexpected changes in user behaviour, which have been described as rebound effects (e.g. Midden et al., 2007). More direct energy consumption feedback, for instance through a smart meter, could play a major role in enabling people to effectively bring down energy uptake in the home. At its most basic, a smart meter measures electronically how much energy is used, and can communicate this information to another device which in turn allows the customer to view how much energy they are using and how much it is costing them. Immediate direct feedback, which means feedback available on demand from the meter or an associated display monitor, could be extremely valuable, especially for savings from daily behaviour in non-heating end-uses. In the longer term and on a larger scale, informative billing and annual energy reports can promote investment as well as influencing behaviour. Savings have been shown in the region of 5-15% and 0-10% for direct and indirect feedback respectively (Darby, 2006). However, despite growing public attention, many obstacles for reducing energy consumption and the acceptance of smart meters exist and even prohibit the implementation on national scale, something what happened, for instance, quite recently in the Netherlands. Obstacles are, amongst others, the complicated and insufficient incentives from public authorities while there are high investment costs involved, negative user experiences (due to automation problems or usability issues), uncertainty about privacy issues with the data exchange between the users home and the energy company, and prevailing concerns about radiation.

Still, even with proper feedback systems rebound effects may occur (Hertwich, 2005). For instance, in a recent research in the Netherlands, for which questionnaires were sent among 300 households, it was found that households that have an automatic programmable thermostat have a higher energy use than households that manage their heating system manually and houses that are better insulated have slightly higher temperature preferences than older houses (Van Dam, 2010). Apparently, everyday ways of living tend not to be predictable in terms of energy uptake and when devices are introduced it influences daily routines, which in turn may influence other types of resource consumption. There's a rising body of literature, originating from social sciences, into a more fundamental understanding of people's everyday life to think about environmental sustainability in the socio-cultural context of the home (e.g. Shove, 2008).

In the field of energy design, it is attempted to take this up, for example, in a student design project in the Netherlands (Papantoniou, 2009), in which it was studied how energy awareness changes with feedback through smart metering, how this feedback is taken up by participants, and how daily knowledge is shared and compared between participants. The project aimed to explore how people can shift from practical to discursive consciousness, e.g. Spaargaren (2003), Dahlstrand and Biel (1997), and Lewin's Change theory (Schein, 1996), when they are provided feedback, or in other words when people go beyond energy awareness, and also start acting differently to change their energy uptake. Results showed that people want to understand their house, the energy they use and how the consumption is distributed to their appliances. There is an urge to monitor consumption, and get more information about energy usage and its costs, whenever people want. Moreover, people need benchmarking points that can help them to understand where they are regarding their energy consumption, and set goals about where they want to go, as long as they do not go against people's comfort zone. People also want to share a common understanding within their family about energy, while they are willing to collaborate with their neighbours and friends. Aspects for changing behaviour comprises for example the comparison with a standard household, analysis of own consumption behaviour, visualization of actual uptake reduction as well as identification of 'major electricity users'.

Given the aspects described here to enable people to change their energy uptake in the home, the aim of the present study was to create innovative ideas for smart metering in various climate and cultural regions. The case study was carried out within an EU funded project for the design of a novel research infrastructure called Living Lab project[1], which aims to study the interactions of users with and stimulate the adoption of, sustainable, smart and healthy innovations in the socio-cultural context of the home (Bakker et al., 2010).

Open innovation sessions

General set up

Since the project did not have the possibility for doing extensive, long term studies into people's daily routines and the purpose of the study was also to make an inventory of ideas for innovations, the methodology of open innovation sessions was chosen. Open innovation is a common applied principle, typically

[1] www.livinglabproject.org

involving mixed types of stakeholders, for instance for idea finding, or evaluation. Open innovation is defined as (Chesbrough et al., 2006):

> "Open innovation is the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively. [This paradigm] assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology."

At first, we aimed to organize completely identical sessions following a structured format for different countries, which would make results comparable. The sessions were to be carried out in three different European countries Switzerland, the Netherlands and Spain.

Beforehand issues concerning IPR (Intellectual Property Rights) were settled within participants' official statements that ideas resulting from the sessions were collective property of the participants of the specific session. Participants involved both experts and company executives from various companies in a country. Users of smart meters were not included at this point of the process since there were various user studies available, which defined obstacles and user issues of smart metering. These studies were presented in the sessions.

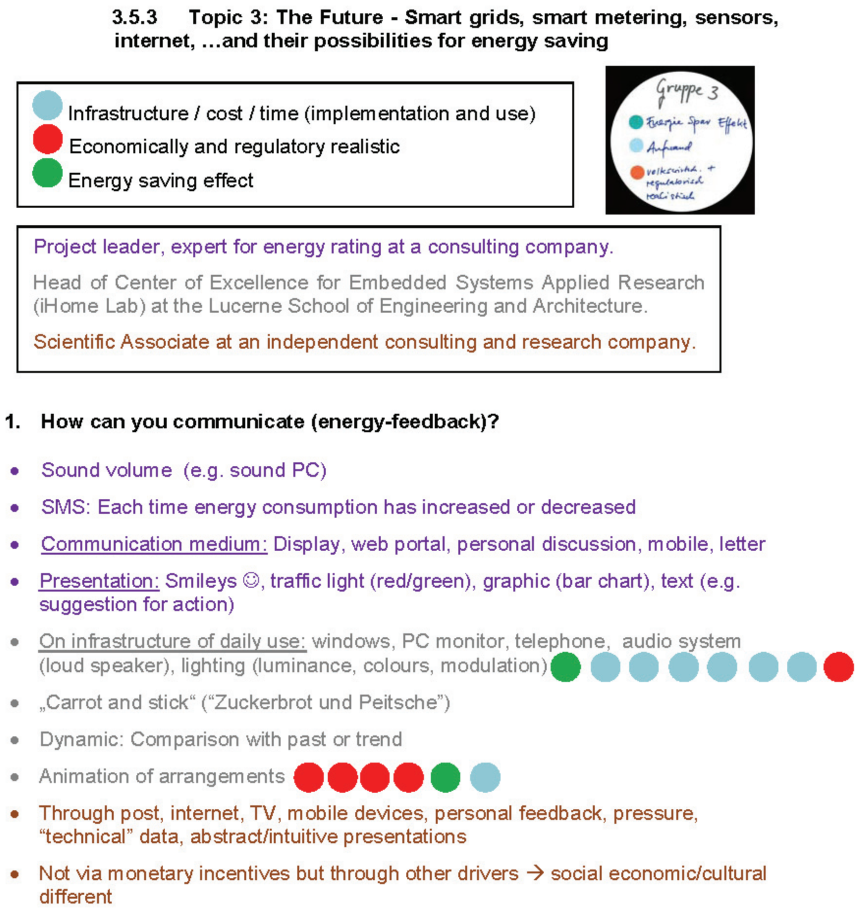
However, due to organisational and practical considerations, only the sessions in Switzerland and The Netherlands followed the structured format, but the session in Spain was organised differently. The differences in set up will be explained in the following paragraphs.

Methods open innovation sessions in Switzerland and the Netherlands

The sessions were structured into two parts divided by a break. The first part was to inform about the LIVING LAB project and smart metering in general and the second part was the creative part for idea generation. The participants were split into three groups. In the second part, the groups had to generate, select and present ideas related to one of the three central topics: The first topic was about how energy-awareness devices can be widely adopted through increasing the acceptance and overcoming hurdles. The second central topic focused on the user involvement in energy saving and on how the behavioural change can be consolidated, and the third topic dealt with the future of smart grids and smart metering and their possibilities for saving energy.

The sessions have been applied according to the open innovation principle, and techniques applied within the session were borrowed from creativity triggering and codesign methods (see also De Jong et al, 2009). The obstacles for smart metering as well as an introduction to the Living Lab project into social innovation were presented to sensitize participants to the topic of social-cultural aspects of smart metering. However, specific studies on smart metering were presented only in the Dutch session.

The method used to find ideas, called the brain drawing session, was based on idea building. A paper with initial ideas of the first participants is transferred to the next person. In total 2 rotation rounds (1 round = each participant had all 3 topics) were conducted. Evaluation of the solutions/ideas was performed by the group. Each group had to develop 3 assessment criteria and relate the criteria to the color code given in the poster template.


3.5.3 Topic 3: The Future - Smart grids, smart metering, sensors, internet, ...and their possibilities for energy saving

Infrastructure / cost / time (implementation and use)
Economically and regulatory realistic
Energy saving effect

Gruppe 3

Project leader, expert for energy rating at a consulting company.
Head of Center of Excellence for Embedded Systems Applied Research (iHome Lab) at the Lucerne School of Engineering and Architecture.
Scientific Associate at an independent consulting and research company.

1. How can you communicate (energy-feedback)?

- Sound volume (e.g. sound PC)
- SMS: Each time energy consumption has increased or decreased
- Communication medium: Display, web portal, personal discussion, mobile, letter
- Presentation: Smileys ☺, traffic light (red/green), graphic (bar chart), text (e.g. suggestion for action)
- On infrastructure of daily use: windows, PC monitor, telephone, audio system (loud speaker), lighting (luminance, colours, modulation)
- „Carrot and stick“ (“Zuckerbrot und Peitsche”)
- Dynamic: Comparison with past or trend
- Animation of arrangements
- Through post, internet, TV, mobile devices, personal feedback, pressure, “technical” data, abstract/intuitive presentations
- Not via monetary incentives but through other drivers → social economic/cultural different

Figure 1. Example of assessment of ideas by colour coded criteria in the Swiss session.

Afterwards, the ideas were assessed by using the assessment criteria. Coloured stickers were used for the evaluation, see example in Figure 1. Finally, each group was given a poster template to be completed.

The session in Switzerland was executed on 7th October 2009 during half a day, see Figure 2. Eight participants from different disciplines as well as from industry and academia in Switzerland took part in it. Location for the session was the Value Lab at the Swiss Federal Institute of Technology in Zurich. The Value Lab is a research and teaching space with five interactive touch LCD panels, a high-resolution video projector and a video conferencing system. This collaboration environment was used during the second part of the session to document ideas and for the poster presentation, see also Figure 2.

Figure 2. Creative Workshop at the Swiss Value Lab (top left), presentations in ESADE Creápolis in the Spanish session (top right), poster presentation in Dim Lab Delft (bottom left) in the Dutch session, and example of creating a poster in the Swiss session (bottom right).

In the session in Delft on 23rd March 2010 (half a day), see Figure 2, 13 participants with different backgrounds from Dutch industry and academia participated. Location for the session was the DIM-Lab at the faculty of industrial design engineering at Technical University in Delft. The DIM-Lab is a research space with a large LCD screen for presentations and recording facilities. A researcher from Delft University was present at each session. The sessions were recorded by cameras and microphones.

Systematic analysis was done by each session organizer who made a list of the issues mentioned for the three central topics, and an inventory of the ideas. The Delft researcher collected the data and performed content analysis of the results of the three sessions. This was done by looking for similar remarks and issues mentioned for the topics and by comparing the ideas within the three sessions. In the Swiss session, a questionnaire was distributed among participants with questions about the use of the facility and the set up of the session.

Method open innovation session in Spain

The Spanish session aimed to promote the benefits and tools of open innovation by facilitating the cooperation between companies on innovation projects. Objectives were to identify different internal business opportunities around smart metering and to promote quality networks between different public and private organizations.

A local facilitator has been involved to create a setup that was specifically aimed at finding business opportunities for the participants. To create an open atmosphere where participants were stimulated to think beyond current barriers for smart metering, focus was put on how to make smart metering more attractive to both consumers and producers and to find innovative ideas for that. During the start up, trends in smart metering were presented by the organizer. There were no introductions by experts on studies of smart metering since, as was stated before, the session organizers intended to break away from current problems, to avoid limitations in creativity thinking.

The Spanish session was held on 3rd December 2009 during one full day at the ESADE Creápolis in Barcelona, see Figure 2. ESADE Creápolis is a creative business center where various organizations are located with the aim to facilitate and stimulate cross innovation. The session in Spain involved 10 participants from different disciplines, including one with a behavioural background, as well as from industry and academia, of which a couple were located within the ESADE Creápolis center. The participants are persons who belong to organizations that are interested in smart metering, or manufacturers of smart metering etc. For a dynamic group, not only technical profiles are included, but also companies closer to the end customers are invited.

The session was divided in two parts: First, participants were familiarized with the concept of creative sessions, the focus of the session and the project Living Lab. In the second part the participants worked on creating ideas, clustering, and rating ideas, before presenting them in groups.

Before the session, participants were asked to send an email about their previous work. Also calls were made to several participants to see if they could provide some interesting data to the session.

Analysis was done by listing the ideas for innovations that resulted from the session by the session organisers and follow-up activities have been taken up by them to understand the effects of the open innovations session by contacting some of the participants afterwards.

Results

Innovations for smart metering

The ideas for innovations that resulted from the sessions were very similar, despite the different set-ups of the sessions. Detailed information on the outcomes is provided in the documentation of the project available through the Living Lab project website, but due to confidentiality issues (IPR) the results will be summarized here. In all sessions it was clear that an important aspect of increasing user acceptance and energy awareness is that energy consumption must be a tangible product or service, such as mobile apps or a physical object with interface. To promote energy as a tangible product it should be established through TV, famous people (from music, politics etc.), education for children (schools), as a brand, through an application, or in terms of a competition with your neighbours, friends or similar households through, for instance, social networks.

Users should be engaged not only through a simple smart meter but energy saving should be an integrated part of their daily live and routine. They also indicated that different feedback systems are necessary for different cultures, which however do not necessarily relate to climate regions. For instance, among the promising ideas was the call for a modular visualisation of energy related to the socio-cultural types (player, calculator, green, lazy, demographics etc.) of users, which can also change its appearance over time to remain a trigger. This means users can choose their preferred type of visualisation (playful, very simple, number oriented, colours etc.), but can also have a dynamic system that has a different way of triggering them every month.

Methodological reflection

The follow up activities after the Spanish session showed that the companies struggled to integrate the outcomes in their overall business strategy. Apparently, to achieve the aim of finding and realizing business opportunities, the open innovation session should be carefully prepared, possibly by organising individual sessions beforehand, to select suitable participants who are both willing and capable of going in the next trajectory of realizing the ideas resulting from the session. On a more practical level, the setting of the open innovation sessions in the high tech facility of the Swiss session was not appreciated by all participants, and also comments were given on the high number of presentations before the workshop while participants expected to have more time for open discussions.

Another issue concerns the involvement of stakeholders. Although there is a great body of literature on the need to involve actual users or, at least, potential users in the development process of products, we decided not to do that at this stage of the project. Since we gathered a lot of insights through the user-studies we felt that we could replace the actual presence of users by presentation of these user studies. Since it is difficult to assess whether or not their presence would have made a difference, it is perhaps better to formulate our concerns with involving users at this stage, because even though participation of users can bring a lot, there are a number of challenges ahead. For instance, the organization of a participatory event, albeit a short meeting, requires thorough preparation in terms of expectations, abstraction level, expert language, and familiarity with techniques. In other studies where we did choose to involve users (e.g. De Jong et al., 2009), we prepared this intensely by organizing similar sensitizing activities of all group members before the workshop to stimulate proper discussions.

In contrast to our initial set-up, we did not manage to organize identical sessions in different EU countries despite the structured template that we set up at the start. This is mainly due to differences in timing of the sessions but also different opinions from organizers about the proper setup and tailoring it to a specific situation or requests in their country. For instance, in the Dutch session, the presentations of user studies were presented by some of the researchers themselves who went into depth of the problems and issues that people encountered when trying to understand and use the smart meters, while the Swiss session was more concentrated on presenting the Living Lab project as such. In Spain, the organizers wanted to start the creativity session without the limitations of the obstacles as found in the user studies, so they chose not to present the outcomes of user studies.

The idea of organizing identical sessions within Europe, if needed at all, could be questioned. Since there are, in fact, great differences between European countries, in terms of climate and cultural differences which apparently also play a role when involving companies and institutes in joint business activities, it may therefore, it requires a more thorough preparation of interests and expectations of companies and institutes to determine the actual need for identical or similar set ups of open innovation sessions within Europe.

Conclusion

Understanding, changing and consolidating people's resource consumption at home is one of the major issues in environmental sustainability that proved to be a wicked problem, even with the use of proper feedback systems such as smart meters. The study showed that smart meters require targeting different social groups through specific types of branding and social networking. Moreover, commitment for energy awareness and action should be accomplished by a tangible product or service.

Future research is needed in the actual context of the home, preferably with prototypes of smart meters, into people in their daily lives to understand the impact of the devices on daily routines and the effects on resource uptake. Such insights can be used in follow-up open innovation sessions, while taking up the challenges of preparing and following up on these sessions.

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A Meta-Design Approach for Collaborative Process Modeling

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Abstract. Modeling business processes has become a complex design task due to a increasing rate of organizational change. Therefore business process modeling is in search for ways to reach beyond the rigidity of traditional approaches. In order to overcome new challenges, like the involvement of a diverse stakeholder community and variability of models, end-user development (EUD) and collaboration are considered promising instruments. In this paper we propose to enhance collaborative process modeling by EUD concepts. Precisely we apply the Meta-Design guidelines to the domain of business process modeling and present a first prototypic environment for collaborative process modeling along with a case-study. The paper concludes by highlighting benefits and unsolved issues of our Meta-Design based process modeling approach and by indicating the next steps of our research.

Introduction

The variability of business processes and associated process models is a frequently stated challenge in designing flexible and adaptive business process management (BPM) systems (van der Aalst et al., 2003; Kettinger and Guha, 1997; van der Aalst and Jablonski, 2000; Schonenberg et al., 2008; Dadam and Reichert, 2009; Rosemann et al., 2008). While the research focus has mainly been concentrated on creating flexible process modeling techniques and workflow management systems little attention has been dedicated to an in-depth investigation on the flexibility and openness of modeling environments, especially to enable end-user participation in process modeling (Dadam and Reichert, 2009).

Traditionally the process of process modeling follows a linear model with sharply separated phases reaching from analysis to design of a process model and it's instantiation (Weske, 2007). Usually the modeling process is limited to design-time of a system mostly being part of an ex-ante requirements elicitation process. Recent research streams challenge this approach in various ways. For example Dadam and Reichert (2009) have shown approaches for a run-time extension or modification of process model instances which can be fed back to the original process model. Thus, a shift from linear models to spiral models or incremental approaches can be observed. The process of modeling can be seen as a continuous process involving multiple stakeholders and has to satisfy multiple perspectives which might as well change over time. Although not yet sufficiently addressed in research the importance of stakeholder participation has been stated in several empirical studies like Davies et al. (2006).

Organizational context however requires tools which support a flexible and easy participation in the modeling process and which are themselves flexible enough to be adapted to a changing environment. Hereby, the emerging paradigm of end-user development (Lieberman et al., 2006) and research initiatives in the field of collaborative design offer promising approaches for the engineering of open modeling environments to foster the integration of diverse stakeholders into the modeling process.

In this paper we argue that through flexible and open modeling environments the effective involvement of end-users into the modeling process can be supported. As a starting point for our research we articulate challenges of collaborative process modeling and use a Meta-Design approach suggested by Fischer and Giaccardi (2006) to derive key features for a respective modeling environment. We present a preliminary wiki-based prototype for user-driven collaborative process modeling and a case-study. Finally, we conclude by discussing our experiences and open issues of our research work.

Challenges of collaborative process modeling

As a starting point to depict the challenges experienced in collaborative process modeling we will refer to an adapted life-cycle model of a process model frequently proposed in literature (van der Aalst and van Hee, 2004; Weske, 2007). The life-cycle model reveals typical stages of a process model reaching from an initial design idea to a more or less formalized process model.

The life-cycle of a process model is determined by the purpose of modeling (Becker et al., 2000). One predominant purpose is the documentation of "as-is" processes to identify shortcomings and potential improvements. As-is models also serve as a knowledge base for participants in a business process. In many cases it is important to model a "to-be" state of a process. To-be models help businesses to understand organizational and financial impact of a new process or process change (Speck and Schnetgöke, 2003). Another purpose is the creation of models that can be used as a basis for process simulation or can be transformed into an executable model description (mostly referred as workflow). Hereby, a major challenge deals with dissolving the sharp distinction between "to-be" and "as-is" models thus leading to process models which are close-to-reality at all time of business operation.

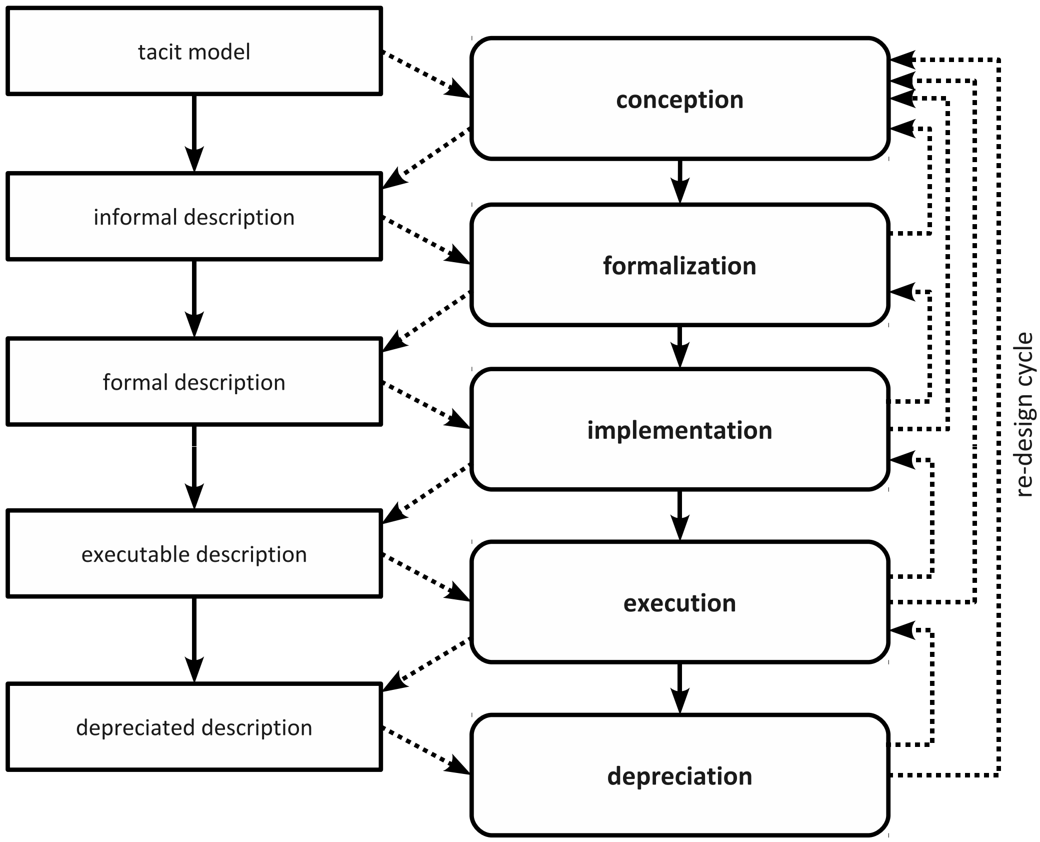

Figure 1. The process model life-cycle showing the different phases and related model representations.

Concerning the artifact as the outcome of collaborative modeling such a process model is characterized by complexity and volatility (Cardoso et al., 2006; Gruhn and Laue, 2006). Complexity is caused by the number of variables that determine a process. Process models are typically constituted by structural entities such as activities, flow logic, events, conditions, decision nodes and attributes like costs and resource allocation. Volatility arises as processes and therefore process models have to be adapted to an increasing rate of changing conditions. A process model artifact runs through a life-cycle starting with a tacit model and ending with a more or less formalized and executable model description (see Figure 1). Respective tools which claim to support the collaborative modeling process would have to enable the coexistence of multiple representations of a model ranging from informal descriptions of a process (e.g. a narrative text), semi-structured descriptions (e.g. a use-case template), graphical process models (e.g. a BPMN[1] diagram) and ex-

[1] Business Process Modeling Notation, for details see http://http://www.omg.org/bpmn/

ecutable descriptions (e.g. a BPEL[2] description). A closely related challenge is stated by Renger et al. (2008): namely the choice of a good starting point for a collaborative modeling effort, meaning that usually an initial or preliminary model provokes communication and problem structuring.

The process model life-cycle can also be analyzed with respect to the diversity of stakeholders typically involved in the design of a process model. First we can distinguish novices from experts regarding the knowledge about a specific business domain. Second we distinguish along the hands-on skills regarding process modeling and associated tools. A third dimension arises when we consider the knowledge about the design of software systems that rely on a more or less formalized business process model. Fourth, stakeholders in a business process typically have a specific organizational role which imposes a specific involvement or behavior in the life-cycle of a business process. Organizational roles range from managerial roles typically having a broad view on a process to employees focusing only on the process fragments that relates to the tasks they are expected to accomplish. Modeling environments should have not only to support but foster flexible and easy participation of diverse stakeholders along the process model life-cycle. A special case in the spectrum of stakeholders is the role of a facilitator. The importance of a facilitator is stated in several studies (e.g. den Hengst (2005); Vennix (1999)) mainly because it is considered to be vital for reaching shared understanding among stakeholders and transferring different views on a process into a valid model.

The promises of end-user development

End-user development (EUD), as depicted by Lieberman et al. (2006), aims at shifting development tasks from programmers to end-users and thus evolving systems from being "easy to use" to being "easy to develop", primarily to enable users to design software solutions which highly fit to their needs and perceptions. The EUD paradigm has emerged in the field of software engineering and reaches beyond the claim of agile methods (Cockburn, 2007) and participatory design (Muller and Kuhn, 1993) which involve users at design-time in the development process but do not enable them to actively shape applications to their specific needs at run-time. Although rooted in software engineering EUD shares many basic ideas with disciplines like CSCW (Lieberman et al., 2006) and recent phenomena like Web 2.0 or Social Media (cf. the long tail of software by Kraus (2009)).

The basic assumption behind EUD shows commonalities with findings in Business Process Management (BPM). It is the increasing frequency of change and diversity in life-cycles for individuals and for organizations as well as an environment which need an increasing flexibility and adaptivity of technical systems claiming to support the user in his activities. Fischer and Giaccardi (2006) state that "creating the technical and social conditions for broad participation in design activities is as important as creating the artifact itself". The EUD paradigm tries to be applicable

[2] Business Process Execution Language, for details see http://www.oasis-open.org

to any domain involving software support and does not anticipate much about the outcome or object of a collaborative design process. In the case of business process modeling the outcome of a socially enabled design process would be a process model artifact that represents multiple views and does not claim to be in a final state. Thus, process model evolution is considered a natural and ever emergent phenomenon which has to be included by design in any processing modeling technique or tool.

The application of the EUD paradigm to process modeling environments seems – at least from our point of view – to have potential for future research. In this paper we investigate the potentials of the EUD paradigm and in particular the Meta-Design approach by (Fischer et al., 2004) in the context of business process design.

A Meta-Design approach towards process modeling

In order to examine collaborative process modeling under the perspective of EUD, we investigate the Meta-Design guidelines by Fischer et al. (2009). Basically, Meta-Design comprises a set of very generic guidelines which are valuable for developing and providing EUD environments. Due to our focus on process modeling we highlight the important aspects of the Meta-Design guidelines and derive key features for a collaborative process modeling environment according to the specific problem domain.

Addressing design and usage in the scope of EUD (Lieberman et al., 2006), it has to be manifested that modeling itself is considered as the design phase while applying models in business operation or instantiation of workflows in software comprises the usage phase. However, the border between design and usage is very indistinct, as collaboration between different users fosters adaptation of a pre-defined environment during usage.

Moreover and with respect to the "seeding, evolutionary growth, reseeding" (SER) model by Fischer and Giaccardi (2006), the process models do not have to be complete before they can be used (e.g. filed in an archive, inspected by other users, verified by experts, shared within a company or community, etc). For a collaborative approach towards process modeling we even consider that partially incomplete process definitions can be executed in a workflow engine and be complemented by end-users (with different roles) on execution time (Neumann and Erol, 2009).

Support human-problem interaction

The very first Meta-Design guideline deals with the issue that domain experts do not want to be bothered with computers and software problems but with domain-specific tasks and challenges. Due to the complexity of computer systems, process modeling tools and process models, an environment for designing and managing process models must hide non-modeling issues (like operating system facilities, distracting features or disturbing information) from end-users.

Therefore we argue, an environment for modeling business processes collaboratively must provide (1) the facilities for process modeling, (2) support mechanisms for single user interactions (i.e. recommendations of activities and activity sequences for specific situations and problems), (3) visual feedback on the process definition (e.g. highlighting control flow errors), (4) feedback on collaboration with other users (e.g. conflicts through concurrent editing), as well as (5) a catalog of design solutions to typical problems (i.e. pre-defined templates for business processes which could be shared within a company or community).

Collaborative modeling tools must somehow act as a facilitator to enable users to focus on the problem instead of hassling with the tool and provide features to mediate shared understanding.

Underdesign for emergent behavior

The second guideline of the Meta-Design framework addresses the support of a tool throughout the modeling process and recommends to "underdesign" the modeling artifacts to achieve emergence of behavior. It requires that a model artifact is not delivered as a finished product, but allows users to solve parts of the overall problem stepwise thus supporting the concepts of "hackability" and "remixability" of (user-created) solutions.

In the scope of process modeling a tool is required that enables users to modify parts of (probably large) process definitions, to verify and store these fragments of a process separately, and also to share them with others. In sum, users should be able to decompose the design problem (a process definition) into smaller design elements and combine them with other elements which can be even given by other users. Concerning reusing design elements, such a process modeling tool might also consider data given from other users as an additional component for designing processes.

Enable legitimate peripheral participation

As a consequence of user contributions to software (i.e. the overall environment and process models), the third Meta-Design guideline refers to policies and procedures for incorporating this user input for software tools and for making them aware of their influence on the system.

For the context of collaborative process modeling, a tool requires facilities for sharing outcomes of other users, like process models or parts of them. In combination with the last guideline, underdesign for emergent behavior, user participation can also be fostered by allowing "incomplete" processes as well as process fragments, so that users can slowly start to get into process modeling instead of being confronted with large, complex process models and the creation of them. Finally and regarding Fischer et al. (2009), process modeling should also support so-called satellite communities, i.e. spaces for people in a certain domain or working on specific types of processes and process fragments which will be incorporated into the overall environment when mature.

Share control

The forth guideline deals with user control within EUD environment with the particular goal to support different roles in the modeling process as well as in the process. Therefore, the Meta-Design framework proposes to enable users to share control within software systems, e.g. by granting access to artifacts they have created or by authorizing others for certain actions.

Projecting this guideline onto collaborative process modeling, the environment must involve the different stakeholders, as elaborated in the former section, and give them adequate authority (control) according to their responsibility and role. Following the experiences from successful open source projects (Fischer et al., 2009), granting authority attracts user who want to influence the EUD environment as well as the outcomes (the process models).

Due to the collaborative character of our process modeling approach, we highlight two important issues here. On the one hand and with respect to privacy issues in online communities (Dwyer et al., 2007), users must have control over their data and share this control on a fine-grained level. On the other hand, collaborative authoring of documents (Borghoff and Schlichter, 2000) required facilities for controlling edit operations in order to avoid conflicts between different users. Both aspects are relevant for collaborative modeling of business processes.

Promote mutual learning and support

As users have different levels of skills and knowledge, this Meta-Design guideline refers to knowledge sharing mechanisms that encourage users to learn from each others. An EUD environment for process modeling could include tools like forums, mailing lists, chat rooms, and other tools to exchange knowledge among peer users. Current technologies like social networking platforms (Facebook, MySpace, etc.) also apply recommendation strategies to support users in working with a system and connecting them to peers.

All in all, an environment for process modeling requires strategies for supporting users in using the design facilities, finding relevant artifacts (e.g. templates or fragments of process definition) and peers (e.g. expert in the same domain or the owner of a relevant business process), and fostering practice sharing within a community.

Reward and recognize contributions

Similarly to the last guideline, this one addresses the need to motivate users for actively participating in the evaluation of the EUD environment, precisely by rewarding and recognizing their contributions. As motivation of human beings can depend on many (intrinsic and extrinsic) factors, Fischer et al. (2009) postulate that many different strategies could be applied.

In the context of process modeling, contributions must be assigned to users. Apart from simple benefits like optimization of time and effort for an individual contributions must be recognizable. It is necessary that they can be found within a software system, or that they are suggested actively by a platform (as observed at many networking sites). Furthermore, a reward strategy such as explicit user feedback (cf. Facebooks like button or the possibility to comment items) is highly recommended. Finally also statistics about usage or linking of process models and navigation facilities might increase the findability of user contributions.

Foster reflective communities

The last guideline given by Fischer et al. (2009) focus on the utilization of collective intelligence in order to solve complex design problems. Thus, EUD environments should include facilities for collaboration and communication, i.e. to create a shared understanding among domain experts and to build and sustain a community of end-user developers. This aspect is of particular relevance for process modeling, as several stakeholders from different areas are involved into business processes. In accordance with key features derived in former guidelines and functionality of social networking platforms, we propose typical features like sharing, rating, tagging, and commenting process models, enabling collaboration and communication between users, recommending process templates and peer users, etc.

Derivation of key features

Summarizing this section, the left-hand side of Table I gives an overview of the original Meta-Design guidelines which are kept very general and thus applicable for nearly all kinds of EUD environments. Next to each guideline we highlight the key features of a collaborative process modeling environment which relates to this specific guideline.

In the next section we will present a first prototype of a process modeling environment considering at least some of the key features derived from the Meta-Design guidelines.

A Wiki-based modeling environment

In a recent research effort we incorporated EUD principles into a wiki framework to achieve a prototypic open modeling environment. The basic wiki application was built upon a well established and broadly used open-source community platform, namely OpenACS (see Demetriou et al. (2006)). XoWiki – a wiki framework for OpenACS based on the object-oriented, Tcl-based scripting language XoTcl – is currently implemented in the context of numerous e-learning platforms (Neumann, 2007).

The wiki approach seems – at least from our point of view – to fulfill the guidelines proposed by the meta-design framework in various ways (see references to Table I in brackets). First, the wiki system is by design an open environment that

Meta-Design guideline & key concepts by Fischer et al. (2009)	Derivation of key features of a collaborative process modeling environment
1. Support Human-Problem Interaction: avoid computer and handling problems, focus on domains and tasks of end-users	(a) consideration of process modelers and non-modelers, (b) recommendations of possible process tasks, (c) visual feedback of process definition, (d) feedback on collaboration, (e) provision of design solutions (e.g. templates)
2. Underdesign for Emergent Behavior: use simple modeling components to be reused by users	(a) possibility to partition large process models, (b) separate verification and storage of process fragments, (c) sharing of fragments
3. Enable Legitimate Peripheral Participation: provide policies and procedures for user participation, create awareness of influence	(a) involvement of other users (e.g. assigning modeling task), (b) allowance of incomplete processes to be completed by others, (c) possibility of merging process fragments of others into a process, (d) support of satellite communities (see 1.)
4. Share Control: support different roles in the modeling and the process, grant access to artifacts	(a) access permissions for processes and fragments, (b) preservation of privacy in the community, (c) concurrency awareness and control to avoid editing conflicts
5. Promote Mutual Learning and Support: foster knowledge sharing amongst users	(a) practice and knowledge sharing through recommending process tasks, fragments, and peer actors, (b) typical social networking functionality
6. Reward and Recognize Contributions: motivate end-users to participate actively (multiple strategies)	(a) possibility to assign modeling tasks and visual feedback on overall outcome (see 3. and 1.) and user contributions, (b) (implicit or explicit) user feedback on process models (comments, I like button of Facebook, etc.)
7. Foster Reflective Communities: use collective intelligence to solve complex design problems	(a) facilities for collaboration and communication amongst end-users, (b) typical functionality of social networking platforms (sharing, rating, tagging, recommending, etc.; cf. 5.)

Table I. Specialization of the (generic) Meta-Design guidelines for collaborative process modeling.

facilitates broad participation in the creation and modification of model artifacts regardless the characteristics of a specific stakeholder. Second, typical wiki features like descriptive page identifiers, simple linking by page titles, on-the-fly creation of pages that do not already exist and flat structure of content are a good starting point for an open and end-user oriented collaborative environment.

XoWiki supports multiple representations of process models ranging from simple textual descriptions to use-case templates and graphical representations (see Figure 2). The ability to configure the user-interface and the diversity of representations of a model offers each stakeholder an appropriate access point to articulate design problems and find solution suggestions. XoWiki can be configured to allow only strict formal process descriptions through forms and associated validation mechanisms but also may be configured to allow simple (underdesigned) textual descriptions and graphical diagrams (→[3] 1a, 3a). Process models and fragments can be enriched with various media formats like documents, videos, images, audio files, etc. Such rich process descriptions can be collaboratively developed, linked, bookmarked, searched etc. in a single environment (→ 5b, 7b).

[3] We use the right arrow symbol to symbolize references to the guidelines in Table I

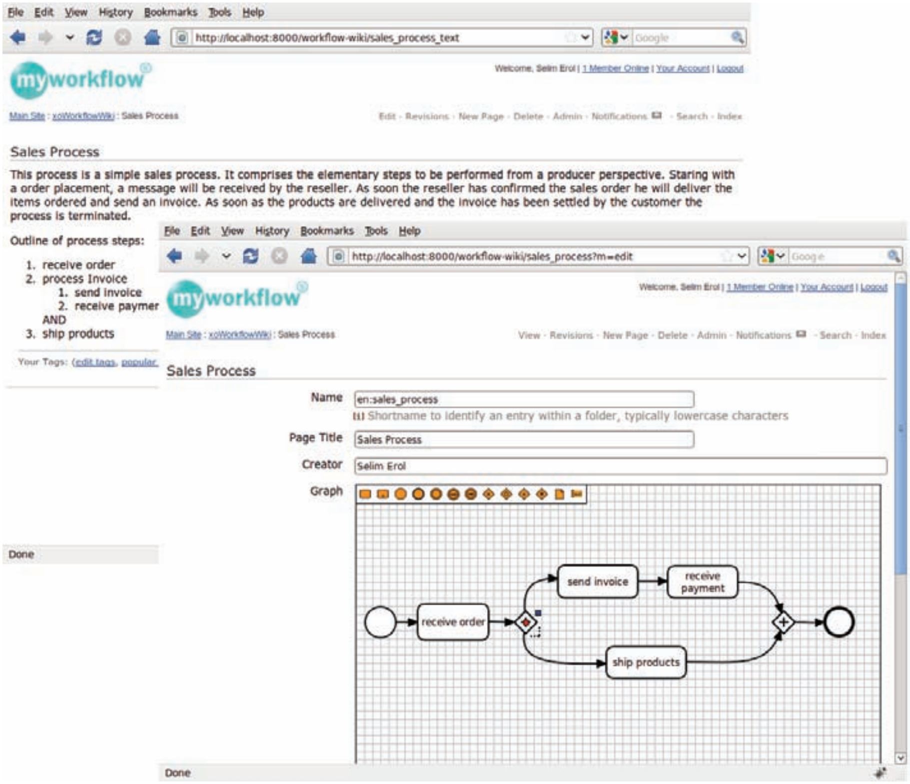

Figure 2. Different user-interfaces representing a textual description of a simple sales process and an associated graphical representation.

Process descriptions of any kind can be divided and linked into arbitrary fragments (→ 2a, 2b, 3b, 3c). Vice-versa process model fragments can be connected to form higher-level models. Apart from vertical fragmentation, horizontal fragmentation is possible by extending and linking fragments to each other. The combination of bottom-up and top-down modeling is considered to support the creation of seeds and emergent design behaviors. In addition to the mechanism for fragmentation of process models legitimate peripheral participation is enabled via typical commentary and tagging functions. Such process model descriptions can be exposed to discussions, reflections and contributions from the community without necessarily intervening the design process (→ 2c, 6b, 7a). The coexistence of different descriptions each reflecting a specific view and state of a process model fosters knowledge sharing and mutual learning among multiple stakeholders. The exploration of comments and revision histories additionally enables stakeholders to learn from the evolution of a process model description.

In scenarios (e.g. in organizations) where a certain degree of control of "who-may-edit-what" is desired XoWiki offers a fine-grained user and role concept to define content policies from complete openness to multi-level access policies (→ 4a). The content flow component of XoWiki (Neumann, 2008) provides explicit state modeling for all wiki objects. By using this component, one can define workflows for the processing of wiki pages. One can for example define release processes, complex page flows or other user interaction sequences. The workflow is based on the state design pattern (Gamma et al., 1995) and can therefore provide a different behavior and/or different presentation depending on the state and the defined user roles (→ 4a). This mechanism can also be used to define the development process of a business process models. One can offer different user-interaction controls at design time of the business process models, or define release steps, or simply make the state of a modeling fragment explicit.

Through the concept of activity graphs (Neumann, 2007) the system provides an awareness mechanism which reveals individuals contribution to a process model (→ 1d, 5a, 6a).

The process modeling wiki described is fully implemented as a prototype that can be used for a web-based shared development of business process models. So far, we have not evaluated the system in the larger scale but we have conducted first usability studies and a case-study which will be described in the next section.

Case-study: a book order process at New Media Lab

The Case

At the Institute of Information Systems and New Media at the University of Business and Economics in Vienna we have recently decided to support our book ordering process by means of software. The basic idea was to enhance the existing process which was characterized by multiple entry of the same data and mostly outdated information on the book's actual location and availability. This resulted from the use of multiple applications (e-mail, local database application, library catalog) to order a book and store data on a book. The administration of the book records by office staff lead to an out-of-date information on the books' actual location and availability. This was mainly due to the fact that staff members exchanged books without informing the office management. The meta-data (author, title, year of publication, ..) of a book proved to be incorrect or incomplete in many cases. The process knowledge which existed tacitly scattered among the different parties involved was not externalized in any way.

In order to capture the different views and knowledge of the "as-is" process we used the wiki-environment proposed above. Therefore we created some introductory pages and also linked to external resources, especially for tutorials on the modeling technique to be used. The introductory pages can be classified in information about the general use of the wiki, information about the purpose and goal of the case-study and information on how to contribute to a process model. We also included a sample process model and a preliminary and yet very high-level model of the book order process.

Along with the invitation of the stakeholders we conducted a short individual training to explain the background of the task and give some motivational support. The stakeholders finally involved comprised five members of the scientific staff both at senior and junior level, the head of the institute and our office management staff.

While scientific staff partly had expert modeling skills the employee responsible for book administration did not have any knowledge about process modeling.

Lessons learned

The case-study presented reflects a typical situation in process modeling. The capturing of the "as-is" process is the basis for a continuously evolving "to-be" process model. In the following we will outline selected experiences we gained during this study.

During our introductory face-to-face sessions at the beginning of the modeling we frequently experienced the objection that this process is that simple that it can be described in one sentence. We traced that back to the fact that each stakeholder only had a limited view on the process and therefore initially underestimated the complexity of the process. With the course of the study and the increasing number of contributions these objections became obviously invalid.

Although the office management staff member had no modeling skills she could quite accurately describe the sequence of activities, conditions and information objects involved in the process. To externalize her knowledge she used a simple wiki page with a built-in rich-text editor. The representational style she has chosen was narrative and semi-structured with bullet points. Her contribution proved to be a valuable input for modeling experts.

During the starting phase reflections on the model to be created were mostly dominated by concerns about how to use the tool. This valuable feedback for further development of the tool somehow contradicts the first guideline of the meta-design approach which demands that a respective tool should not hinder human-problem interaction. However, the reflections on the tool abated with the further use of the tool. Another issue that led to discussions during the design process was the usage of symbols for modeling links to other process fragments or sub-process pages.

Some of the participants commented on the usefulness and usability of the tutorials without recognizing the possibility to contribute or change them the way they want them to be. We have to say that we did not stress this possibility explicitly in the introductory session. We continuously modified and extended the learning materials during the study according to user comments.

Although initially intended to have a high level process model developing into detailed sub-process models we experienced a fragmentation taking place from the very beginning. This was due to the fact that some of the modelers feared the interference with other modelers working on the same page. A first analysis of revision histories of the model fragments revealed that some participants contributed many revisions over several weeks. Others participated once contributing only one revision.

The role of a facilitator proved to be important in two ways: First, participants needed a introduction to the task as a starting point for their contributions. Second, a kind of linking and alignment had to be performed to integrate individual modeling efforts.

The preliminary results of the case-study will enable us to reflect on the validity of the guidelines proposed for collaborative modeling. For further evaluation we will have to involve a broader audience into the modeling process (e.g. the company responsible for shipping the product, library service) and observe the evolution of a process model over a longer time-period.

Related work

Renger et al. (2008) summarized the most prevalent challenges of collaborative modeling found in literature in the fields of problem structuring methods, group model-building and enterprise analysis. One of the key issues is the importance of a facilitator in the modeling process. Other key issues are the choice of a starting point and modeling in parallel. The literature review is comprehensive but is focused on providing a general (high-level) analysis of challenges in collaborative modeling. Nonetheless, this served us as a basis for more concrete challenges especially when it comes to requirements for tool support.

Recent empirical work was also conducted by Rittgen (2009, 2010). In several experiments, case-studies and interviews he investigated business needs and success factors for collaborative business process modeling. He studied practical business experiences and needs in collaborative modeling. Although Rittgen's studies provide a valuable basis for our approach it is actually limited to small and expert oriented groups and does not provide insights when it comes to open modeling environments where the community of participants is not predetermined.

Decker et al. (2007) have investigated the use of wikis in requirements elicitation. They provide an outline of advantages in using wikis compared to other tools. Many of the propositions are equally valid for collaborative process modeling. In (Decker et al., 2004) a methodological approach and platform is presented for participative process modeling and learning. Results of three case-studies show that higher user acceptance and perceived model quality can be reached through user participation. A process modeling method especially designed for user participation is suggested by Becker et al. (2007). The approach consists of a set of language constructs and a procedure model which "allow for an easy and straightforward modeling of a public administrations process landscape". The researchers proved the applicability of their approach in several projects.

Concerning tool support for collaborative modeling we want to outline two distinct developments: one approach is presented by Hasso Plattner Institute and has integrated a web-based modeling editor into Google Wave (Hasso Plattner Institute, 2010b; Dreiling, 2010). Thus, allowing users collaboratively annotate and communicate on process models while actively modeling. The same research group has launched a community portal for sharing and collaboratively editing models (Hasso Plattner Institute, 2010a). Another development is an open platform for sharing scientific workflows (Roure et al., 2007).

Conclusions and outlook

In this paper we highlighted challenges and problematic aspects of collaborative process modeling and proposed to apply concepts of end-user development to enhance process modeling. We also tried to come up with a EUD based approach towards collaborative process modeling which is based on the Meta-Design guidelines. As a first proof-of-concept, we presented a prototypic environment which is designed according to the Meta-Design guidelines for process modeling.

Overall we think that the complexity and volatility of designing business processes requires such a step towards an open and collaborative design process. At this early stage of our research it is already apparent that specific aspects – such as the emergent behavior through under-designed, the active involvement of stakeholders, scaffolding and mutual learning support, rewarding and reorganization mechanisms, as well as reflection and community aspects – are of particular relevance for an open process modeling environment. To underpin this assumption we have derived key features for such modeling environments from the Meta-Design framework and incorporated them partly in a wiki-based modeling environment.

Although we have not realized all key features, we have developed a prototype modeling environment that is intended to be an open design space where stakeholders are encouraged to contribute and share knowledge regarding processes. For instance, stakeholders are able to design process fragments within their scope of responsibility and according to their domain knowledge. These specialized parts of process models can be shared, reused and improved. Stakeholders are not limited to one representational style of a process model (e.g. a process BPMN graph) but are able to contribute in various ways (e.g. simple textual descriptions or comments). The wiki-based modeling environment is not limited to support the continuous and user-driven evolution of process models but allows also to collaboratively develop associated artifacts like tutorials and other learning resources. Finally, the modeling environment has also to be considered as subject of continuous evolution. Thus, feedback mechanisms should not only be targeted at the design object – in this case a process model – but also at the tool claiming to support the design process.

A case-study was conducted to validate the prototype modeling environment along with the theoretical assumptions. The preliminary results of the case-study show us that the users involved reflected both on the modeling object and the modeling environment. We experienced remarkable differences with regard to the extent of contributions from individuals and the type of contribution (e.g. informal vs. formal). During the case-study we also observed a strong need for instruction and facilitation during the modeling process.

In sum, this leaves us two important issues to continue research work. On the one hand, it is necessary to develop an evaluation framework for process modeling environments which claim to support organizations in collaborative model building. Similar prototypical attempts from other research groups (see e.g. Hasso Plattner Institute (2010b) and Roure et al. (2007)) encourage us to establish a framework that provides basic theoretical concepts to collaborative modeling and furthermore forms a basis for evaluation. On the other hand, we will go on with development work on our wiki-based modeling environment and also evaluate it in the form of user studies and ex-post data-analysis. We will have to rigorously study the impact of different collaborative features on modeling outcome.

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Biographies

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Andreas Butz studied Computer Science in Saarbrücken, Germany. After his PhD in 1997, he spent a year at Columbia University, New York as a PostDoc. In 2000 he founded a company, which now has 14 employees, and in 2003 he returned to academia and became a full Professor for HCI at the University of Munich in 2004.

Bettina Conradi studied human-computer-interaction and software engineering in Augsburg and Munich, Germany. During her studies she was working on multitouch and tangible interface projects, which were awarded (extraordinary engagement (Microsoft), visitor's favorite (Lab30, Augsburg), most innovative idea (TEI '08)) and even resulted in a museum exhibit. Afterwards she started her Ph.D. studies at the University of Munich. Her research interests are development methods for ubiquitous computing, especially for tangible and physical interfaces.

Sebastian Draxler is a research associate at the University of Siegen. Currently, he is working on appropriation support for flexible, component-based software systems through a general infrastructure. He is interested in the fields of Human-Computer Interaction, Computer Supported Cooperative Work, user participation and agile software development, combining ethnographical methods and the design of information systems.

Selim Erol is a researcher and PhD candidate at the Institute of Information Systems and New Media at the Vienna University of Economics and Business. Prior to his academic career he gained ten years of practical experience in industry working as software engineer, consultant and project manager. His research interests are focused on business process management and modeling, collaborative process modeling and workflow management.

Regina Hardziewski is working as a research assistant at the Chair of Sustainable Construction within the Institute of Construction and Infrastructure Management at the Swiss Federal Institute of Technology Zurich (ETH Zurich) since March 2008. Research areas are certification systems for sustainable buildings, sustainability and real estate valuation, sustainable living in a European funded project for the design of a Living Lab as well as the implementation of a common European transparent building assessment methodology in the framework of an EU funded project. She is also involved in LEED certifications within her part time work at Intep, a consultancy for large-scale projects and management consulting for real estate companies, since September 2010.

Heinrich Hussmann holds a diploma degree in Computer Science from Munich University of Technology and a doctoral degree from University of Passau and was awarded habilitation by Munich University of Technology. He has worked at universities in Munich, Passau and Dresden and in the telecommunication industry. From 1997 to 2002 he was full professor for Computer Science at Dresden University of Technology, and since March 2003 he is full professor for Computer Science (Media Informatics) at Ludwig Maximilians University of Munich (LMU). He is author of over 70 refereed publications, including three books.

Annelise de Jong has been affiliated as Assistant Professor in Delft University of Technology, Industrial Design, the Applied Ergonomics and Design group, since 2002. Research areas are usability evaluation of domestic appliances and sustainable living in a European funded project for the design of a Living Lab. Within the Interactive Institute in Sweden, Stockholm, she has been involved in the Design Research group since May 2010, as guest researcher.

Miriam Kranz is a student of media informatics at the University of Munich. During her thesis she evaluated and extended SourceBinder and built exemplary projects with it.

Steffen Lohmann is member of the Laboratorio DEI and the Instituto de Cultura y Tecnología at the Universidad Carlos III de Madrid. Steffen's research is devoted to all exciting topics related to Human-Computer Interaction, Knowledge Management, and the Web. In particular, he is interested in issues of web usability, interaction design, and knowledge sharing. He investigated these topics in several research and development projects in the areas of software engineering and technology-enhanced learning, among others.

Felix Mödritscher received an MSc in Computer Technics (2002) and a PhD in Computer Science (2007) from Graz University of Technology. In the scope of various research projects, he has been dealing with personalisation and adaptive behaviour in e-learning systems, infrastructures and services for technology-enhanced learning, as well as personal learning environments and learning communities. Currently, he is a postdoctoral fellow at the Institute for Information Systems and New Media of the Vienna University of Economics and Business.

Pirjo Näkki has worked as a research scientist at VTT Technical Research Centre of Finland since 2003. She graduated with a M.Sc. Tech in Information Networks from the Helsinki University of Technology in 2006 with Human-Centred Information Systems as a major subject. Currently she does her PhD on online methods for user driven innovation. Her work and studies relate to user-centred design, user experience and usability, social media and online collaboration. She is especially interested in open innovation and user participation in early product concept design.

Gustaf Neumann is appointed Chair of Information Systems and New Media. His research is focused on the constructive and creative use of new media (e.g. Internet technologies) in business and not-for-profit organizations, especially in the context of knowledge transfer and knowledge acquisition. His main goal is to design and develop new information spaces for interaction of users and software for the advancement of the knowledge society. Gustaf Neumann was a visiting scientist at IBM's T.J. Watson Research Center in Yorktown Heights, NY, from 1985-1986 and 1993-1995. Gustaf Neumann has been heading the EC IST project UNIVERSAL (see also the resulting platform EducatNext), the IST Project Elena and is a member of the Steering board of the Network of Excellence ProLearn. Gustaf Neumann is the author of several widely used open source software packages, such as the TeX-dvi converter dvi2xx, diac, the graphical front-end package Wafe, the Webbrowser Cineast, and the object oriented scripting language XOTcl. Gustaf Neumann is a member of the board of directors of .LRN, an open-source enterprise-class learning management system.

Asarnusch Rashid is a researcher at the Research Center for Information Technologies (FZI), Karlsruhe, in the Information Process Engineering group. He has been working in several research and development projects in the domains of Software Engineering and Health Care. His research interests include new methods and tools for Usability Engineering, User Innovation, Requirements Engineering and Computer Supported Cooperative Work (CSCW).

Balázs Serényi is head and co-founder of Visual MINDS, a multidisciplinary development studio where programmers, visual artists, web designers and IT professionals work together and join forces to create digital masterpieces. Leaving the math class Balazs popped into the world of security systems, GIS solutions, math-driven ERP and data visualization. Through the years he and his team specialized themselves in utilizing graph theory to solve the puzzles of today's information science. And because from the beginning they've been into visualization, they just had to tell their own thoughts on a visual programming environment. Since the launch of FlashFilterLab in the year 2006, Balazs holds workshops and presentations on using flash and physical computing in new media and experience design.

Gunnar Stevens is an assistant professor at the University of Siegen. He published several articles about appropriation support and the topic of mediating situated software appropriation and public design discourses. He is interested in qualitative design methodologies and co-developed the Business Ethnography method for reflective technology development.

Alexander Wiethoff is a passionate interaction designer committed to developing and implementing visionary strategies that support architectural, industrial and interaction design objectives. Prior to working as a HCI researcher at the University of Munich he was teaching at the Copenhagen Institute of Interaction Design (CIID) GUI /TUI and Rapid Prototyping courses for two years. At the internal consultancy at CIID he was developing projects for international clients such as Nokia, Intel and Novo Nordisk. Before his time at CIID, Alexander worked in Italy for two years, where he led key initiatives at Syneo Srl. (Milan) including the setup of an interaction design lab and interactive trade show experiences. He holds a BA in space&designstrategies from the University of Linz (A) where he graduated with distinction and an MA in Interaction Design from the Interaction Design Institute Ivrea / Domus Academy, Milan. Currently his key research focus is the analyzation of design processes in the area of pervasive computing, the creation of work process tools that support communication of multidisciplinary teams and the design of usability testing methods in this domain.