Understanding and Designing Appropriation Infrastructures:

Artifacts as boundary objects in the continuous software development

Dissertation

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Abstract

Co-production among product communities has turned out to be a major challenge for the software industry. There is a growing need for evolutionary development strategies supplemented by means of interweaving software production and software use more efficiently. In this scenario, the Internet offers a ubiquitous transportation infrastructure for digital products, and impacts the communication culture. However, opportunities to mediate between consumption and production (needs and solutions respectively) within software communities are under-investigated, empirically, theoretically and in terms of design methodologies.

Framing the design issue to enable new forms of co-production, I investigate in the first part of my thesis the corresponding theoretical problem of mediating innovation development. From a Marxian understanding of appropriation, I show how philosophical, sociological, and technological aspects of mediation are related to each other in the case of innovation development. Moreover, the diverse theoretical positions in Design Science research suggested in literature can be compared in respect to the question of mediating needs and solutions. Regarding this question, I develop a personal Pragmatistic position rooted in a dialectical understanding of praxis, which synthesizes different non-positivistic streams in IT research (especially Wulf/Pipek, Orlikowski, Suchman, Star, and Rittel/Webber).

My theoretical studies imply a paradigm shift in user-centered innovation research. Complementing studies on individual motivations for user innovations, my thesis uncover the work structure of making wicked situations accountable across social worlds to generate situated innovations. From this position I figure out the role of the socio-material artifact as a boundary object mediating distributed appropriation and production.

In the second part of my thesis I demonstrate how the analysis of wicked situations can be interpreted in terms of design. I present my concept of Appropriation Infrastructure, which is a novel design solution for interweaving distributed production and use, based on the specific qualities of digital products. Implementing a first instance of Appropriation Infrastructures, I follow a user-centered approach that supports the appropriation work in its situated and social dimension. In the tradition of End User Development (EUD) it supports users to change the material and the symbolic construction of software artifacts and - going beyond traditional EUD approaches - to articulate these situated development across product communities. In my solution, EUD-tools are interwoven in the context of a wicked situation to inquiry into the situation as well as in the design of situated innovations. Here, the artifact present-at-hand serves as a boundary object to mediate and translate a diversity of mean-

ing constructions and to make the innovative potential of a wicked situation accountable. To support the situational talk-back of the user as a reflective practitioner thinking about wicked situations, rooms for private conversations are offered and options are provided to integrate colleagues and friends, as well as a public product community. I have evaluated this first instance of Appropriation Infrastructure by means of a long-term study focused on users and designers and their mediated activities.

Taken as a whole, my thesis presents a theoretical model of appropriation and a technical solution for appropriation support, which shows how non-positivistic Information System research can be combined with Design Science research to support new forms of co-production within software communities.

Content

1 Introduction

This thesis is about the mediation of production and consumption in today's ever more continuously distributed development of software.[1] It studies this complex from a user's perspective on the appropriation and articulation of situated innovations that emerge in the use context, and asks about the mediating role of the artifact present-at-hand.

The production and consumption of innovation in society as well as in the realization and appropriation of innovation in situated action is a highly relevant research topic in Cultural Studies , Innovation Research (Rogers, 2003a, von Hippel, 1994, von Hippel, 2005), Information Systems (Orlikowski, 2000, Boudreau and Robey, 2005, Jones and Karsten, 2008, De Sanctis and Poole, 1994) as well as Software Engineering (Fischer, 1998, Messerschmitt and Szyperski, 2004, Raymond, 2001, Floyd et al., 1989) (see Chapter 2).

At the same time, this is an old topic, discussed in depth in 19th century theories of evolutionary economy (cf. Reinert and Reinert, 2006). In general terms, these analytical results about the dialectic mechanisms in mediating emerging objects even hold today (see Chapter 3). However, I will demonstrate in my thesis that modern digital infrastructures and practices enable new forms of mediation, where the software artifact serves as a boundary object in situated innovations (see Chapter 4). Against this analytical backdrop I present the implications for design (see Chapter 5) and show with the Appropriation Infrastructure a first implementation that demonstrates on a practical level how the new forms can be supported by a different design methodology (see Chapter 6).

In this chapter, I give a brief introduction to my research topic and to my contribution to constructional as well as to analytical Information Systems (IS) research. Section 1.1 outlines the practical challenge *to support* and Section 1.3 the theoretic challenge *to analyze* the mediation of distributed evolution. Moreover, I present the contribution of my thesis in answering these challenges. Section 1.2 presents the method of this endeavor. From a methodological point of view, I also discuss in Section 1.2 the linkage between analytical

[1] On a general level, mediation presents an analytical category to pinpoint the question, how to conceptualize the relationship between two categorical different entities that analytically creates a unity. In philosophy the common example is the question, how mind and body is mediated. In sociology it is the question, how social order and individual behavior is mediated. In Information System research, it is the question, how technology design and technology use is mediated. Fragmentation, in this context, refers to the fact that from an analytically or normative point of view should be mediated, however empirically one can observe an absence or the underdevelopment of mediation.

and constructional research which presents a specific topic in design research (cf. Hevner et al., 2004, Dourish, 2006, Nett and Stevens, 2008). With these materials in hand, I introduce in Section 1.4 the key analytical constructs of my thesis. In addition, I discuss once again the relation between analytical and constructional research, this time at the level of content. Here I hope to show the connection between the analytic construct of situated boundary object and its constructive interpretation in designing the Appropriation Infrastructure. The chapter concludes with a brief guide to and overview of this thesis in its basic structure.

1.1 Practical objective: Supporting distributed evolution

One of the seminal results of the analysis of modern production mechanisms as carried out by evolutionary economists was a demonstration that the need to be continually innovative is not a residual, but an essential economical factor: “Creative destruction is the essential fact about capitalism, stabilized capitalism is a contradiction in terms” (Schumpeter, 1975 - first ed. 1942, p. 83). This trend is increased by globalization of the economy. With increased competition, the competence to be innovative becomes a condition sine qua non to survival (Kelly and Storey, 2000, p. 104). Therefore, almost any company makes considerable efforts to better commercialize their industrial knowledge, to create new ideas, and to provide sustainable growth to reach the competitive position they aspire to.

Unfortunately, empirical research shows that there is a constant high failure rate in the development of innovative products. For example, referring to Booz et al. (1982), Cooper and Kleinschmidt note that about 45% of the resources devoted to product development and commercialization are expended on unsuccessful projects. In addition, they note that about 35% of all products launched fail commercially (cf. Crawford, 1979). An survey of current literature conducted by Kuhn drew a similar picture. She concludes that failure rates are consistently significant, despite the failure rates’ large variance in literature; for instance, Pleschak and Sabisch (1996) suggest a failure rate of 33%, while Sividas and Dwyer (2000) mention a failure rate of 50%. In the case of costumer goods, Andrew and Sirkin (2003) estimate a 50%-90% failure rate, whereas Haber puts forward a failure rate of 80%-90% for this domain.

In his historical survey of failed innovation (like the invention of microwave in the 1940$^{'s}$), Bauer shows that there are no internal factors or even guarantees that enable you to create a successful innovation. There are good reasons why innovation development is not

just empirically, but also theoretically an inherently uncertain and risky endeavor where the *possibility of failure* is not an accidental, but an essential feature.

In spite of the inherent risk to fail, nevertheless a mandatory demand to innovate in at least two cases: in the case of true novelty, and in the case of market saturation. In both cases, product development is a wicked problem, which cannot follow conventionalized criteria to full extent (cf. Rohde et al., 2009) because either a conventionalized knowledge does not exist or it does not lead to any interesting novel products.

It seems that the software industry is dominated by extremes of both cases, so that the need to innovate in a wicked situation does not present an exception, but the rule. For example, at the time Pierre Omidyar launched eBay, he could not rely on conventionalized knowledge that ensures that an online auction platform is a successful concept. Instead, Omidyar decided to launch eBay as an experiment (Schell, 2007, p. 183), which becomes itself a *proof by realization* that demonstrates that online auctioning can be successful. This means that the success of eBay creates the knowledge needed to reduce the uncertainty about online auctions: however, at the same time the market for eBay clones is already saturated by eBay's demonstration of its own viability, rendering the knowledge thus created less immediately useful for other potential innovators without further active interpretation and risk taking.

To be innovative is therefore a structural dilemma for the software industry. The constantly high failure rates of software development projects mentioned in the Chaos Reports document an 'innovation crisis' in software production:

> "[There is a] fantastically high failure rate among software development projects. The Chaos study, published by the Standish Group, found that 26 percent of all software projects fail (down from 40 percent in 1997), but 46 percent experience cost and schedule overruns or significantly reduced functionality (up from 33 percent in 1997)" (Reel, 1999, p. 19).

However, the Chaos report documents not just the specific forms of crisis in the software industry. It also documents emerging strategies to deal with the innovation dilemma, for example, improving the completion rate by smaller, more manageable projects, and by reducing functionality (Reel, 1999). Another strategy that also became popular in the last years is to innovate cooperatively in open software ecosystems (Messerschmitt and Szyperski, 2004, Raymond, 2001) to increase the efficiency of innovation development and spread the risk of failure wider to minimize individual loss.

These emerging strategies make use of the specific character of software production and consumption. Due to its digital character, software is easy to reproduce (Stelzer, 2004) as well as easy to adapt (Lieberman et al., 2006), so that the incremental costs as well as the

costs of incremental changes are dramatically reduced. The software industry is thus characterized by two concurrent yet opposing trends: software becomes a continuously developed mass-product as well as a highly individualized artifact evolving in use. These trends in software production are supported by the Internet as a ubiquitous transportation and communication infrastructure for digital goods, which enables the emergence of new opportunities.[2] Through the new production and consumption forms of software, the managing of development in dynamic ecosystems has become a new major challenge for current Software Engineering.

I will illustrate the new risks and opportunities of distributed evolving software by two examples. The first example is about the distributed evolution of Excel in practice, based on anecdotal evidence conveyed to me by a practitioner. The story starts in 2003, when the mass-product Excel evolved from version 10 to version 11. This triggered the evolution of a local form of Excel in enterprise Beta (from version 8 to version 11). The central IT-department replaces all existing installations in the company with the new one. However, in one department of Beta this leads to a breakdown of a mission-critical applications created by local developers. The technical reason was that the application uses a macro function which was not supported by new version of Excel anymore.

Fragmentation as the absence or underdevelopment of connections between these traces can lead to undesirable effects, so that the distributed evolution ought to be mediated between the autonomous agents. One strategy for addressing this problem is to prevent fragmentation by disabling local adaptations. In specific cases this might be a good solution, but often this strategy is too rigid to work in cross-organizational contexts. There are additional strategies needed to profitably address the risk of fragmentation in distributed evolution.

The second example illustrates a more complex scenario, and the emergence of a novel strategy used in practice to organize the distributed evolution on a public sphere in the case of Eclipse (Beck and Gamma, 2003). Originally, Eclipse was designed as a universal tool integration platform (e.g. used as number one Java IDE). However in 2003/2004, Eclipse evolved from version 2.1 to version 3.0, and one major innovation of version 3.0 was the reconstruction of Eclipse to make it into a highly tailorable Rich Client platform (RCP) (e.g.

[2] With the ubiquity of the Internet, digital material has in recent years attained a new quality. With the notion of 'software', the malleable character of digital goods executed on universal machines is well described. However, the new quality of inter-connectedness is poorly captured by the term 'software'. Adam Greenfield (2006) suggested the term 'everyware' to describe this new quality. I will use the term 'software' since it is well established, carrying the other meaning in mind.

now used by IBM Lotus Notes). This product evolution is a good example of a user-driven innovation (Thomke and von Hippel, 2002), as the re-design was not triggered by the core developer, but by a user of Eclipse. In the public bug tracking system of Eclipse, he suggests to "enable Eclipse to be used as a rich client"[3]. In reaction, this topic was discussed in the Eclipse community, which is partially documented by the 52 comments made in the bug tracking system. In the end, the idea was taken up in the strategic roadmap of Eclipse, and an open discussion about the consequences was organized by the Eclipse Project Management Committee (PMC): "The nature and scope of some of the key plan items are such that the only feasible solutions would break compatibility. Since breaking changes are a *disruption to the Eclipse community*, they cannot be taken lightly. We (the Eclipse PMC) will have *an open discussion with the community* before approving a proposed breaking change for inclusion in 3.0" (Eclipse Foundation, 2004, emphasis by the author).

The example of organizing evolution in a product community demonstrates that fragmentation is not just a technical problem, but closely related with the organization of communication between the relevant social groups. However, we have only just started to gain a grasp of the phenomenon of distributed evolution in complex, dynamic software ecosystems, and of the new forms of mediating the fragmented production and consumption.

Through the increasing relevance of software evolution in complex, dynamic ecosystems, a paradigm shift in analytical as well as constructional research becomes necessary - from a monadic and mechanic view to a holistic, organic view.

The mechanic view rests on the paradigmatic example of software as closed products in static environments. This construct serves as a guiding principle to elaborate theories about software development. Reed's (1999) rhetorical question provides a good example of a mechanic view: "Can you imagine a construction firm completing only 74 percent?" (p. 19). In opposite, the organic view rests on the paradigmatic example of software as open systems in evolutionary ecosystems. A corresponding rhetorical question for the organic view in the age of 'perpetual beta' might sound: "Can you imagine that the construction of a software application will be ever complete?"[4]

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[3] Cf.:https://bugs.eclipse.org/bugs/show_bug.cgi?id=36967 (21.3.2009)

[4] This rhetoric question is related to my personal experience in writing this thesis. I often used the search engine scholar.google.com. Although it is a beta version, it was a very supportive tool for finding relevant work, and it would be difficult to say if the search engine is 74 percent or just 23 percent complete; it is also unclear if the software ever leaves the beta state or if it is constantly under construction. The situation has becomes more complex as my Google looks different since I installed Skype on my desktop.

The organic view of software as distributed evolving artifact is not a self-evident position in Software Engineering. Especially in the beginnings of Computer Science as a discipline of its own, theoretical reflection on software development mainly focused on the transformation of specifications into computer programs. This paradigm emphasized formal correctness, but neglects practical aspects of the development process. By neglecting evolution in and of practice, this concept refers primarily to a static and non-evolutionary perspective on the object of research. It was mainly the emergence of Software Engineering as a genuine research field that has broadened perspectives here.

Research in this field emphasized the importance of production conditions and human resources for the development process. However, the 'ceteris paribus' assumption of approaches like the Waterfall model (Royce, 1987, Boehm, 1976) largely ignores development processes which occur outside the production context. Concepts like the STEPS model (Floyd et al., 1989) have overcome this static element in the perception of software development. In particular, Floyd emphasized that during the entire life-span of a product, there is continuous development of the objects (the software artifact, the application field, etc.) as well as of the subjects (the user, the designers, etc.).

Our understanding of continuously evolving software might be broadened by considering it from a bird's and a worm's eyes' point of view. From the bird's eyes' view, the research on open source projects and software ecosystems (Messerschmitt and Szyperski, 2004) increases our understanding of the mechanisms of innovation development in an open environment as well as of the division of labor in distributed evolving software. From the worm's eyes' view, research on the design activities of end users and appropriation of technology (Orlikowski, 2000, Boudreau and Robey, 2005, Pipek, 2005a) elaborates our understanding of the production of situated innovations emerging in daily life. In addition, the story of Eclipse gives a first impression about the relation of local and global development processes.

In this thesis, I mainly focus on the topic of situated innovation emerging in local contexts, as seen from the worm's eyes' view. In particular, my research by construction follows a user-centered design approach, which is mainly based on the EUD research on local de-

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This example demonstrates that openness makes it difficult to decide when an application is finished and when it is evolving. Technically, this is related to the fact that desktop applications become a dynamic orchestration of products coming from different vendors. Socially, this is related in that applications gain their functionality when they are plugged into socio-technical infrastructures (Tuomi, 2005, Pipek and Wulf, 2009).

velopment activities. However, in studying situated development in the context of distributed evolution, my research benefits from the bird's eyes view on software ecosystems. It helps to think biologically, to always have the big picture in mind for approaching something like an organic paradigm of Software Engineering.

The EUD research established a new perspective on the situated development carried out in the local context. From this new perspective, the demand arises that in-situ design activities should be supported by tailorable software as well as evolutionary development models (Wulf and Rohde, 1995, Wulf, 2001). However, even the perspective established by EUD can be extended by taking not only the realization of design ideas, but also the formation of design ideas into account. EUD research can benefit from technology appropriation research, which shows that software artifacts evolve not only through change of the material form (which used to be the main focus of EUD research), but also through a change in interpreting this material form. It is the merit of the appropriation research of Pipek (2005a) to show the concrete design relevance of the co-evolutionary character of material forms and interpretation schemes. Elaborating on the design concept of Use Discourse Environments, Pipek (2005a) demonstrated that co-evolution of meaning can and should be software-technically supported by IT-artifacts.

Combining the new insights on evolutionary processes in the local use context with the insights on software evolution in open ecosystems, it becomes evident that a software-technical infrastructure is needed which enables the transfer of material objects, knowledge and representations between social worlds. However, existing design methodologies largely neglect that software is subject to continuous, fragmented development in spatially, temporally and culturally distributed product communities. Therefore, it is an under-investigated topic in research how such an infrastructure should look like so as to support distributed evolution in heterogeneous production and consumption networks. In particular, it is an unresolved issue how the mediation features of software can be increased, and how a mediation infrastructure can be integrated into software applications. Therefore, constructional research (Hevner et al., 2004, Nunamaker et al., 1991) should explore new mechanisms to support end users' participation of the distributed software evolution.

This was the initial situation when I started my constructional research to address the problem of fragmentation in the distributed evolution from a user perspective. In my research, I explored in particular the opportunities for increasing the mediating features of software artifacts so as to support users in expressing and discussing situated innovations. Once

grounded in a socio-technical understanding of the problem, I came up with the Appropriation Infrastructure as a novel software-technical approach for utilizing the digital and interconnected qualities of software in order to enable the emergence of new forms of distributed appropriation of and participation in dynamically evolving software ecosystems.
The approach made some important progress by generalizing and combining existing conceptions suggested in the literature to answer the challenge of supporting the situated development of software artifacts:

- It adopts from Participatory Design-oriented Software Engineering the concept of mutual learning (Kyng, 1991), which is part of process models like STEPS (Floyd et al., 1989), OTD (Wulf and Rohde, 1995) or SER (Fischer, 1998). These models include special phases in the software life-cycle where designers and users work together to foster mutual learning. However, taking into account that software continuously evolves in the consumption and production sphere, the Appropriation Infrastructure puts the practice of mutual learning to the extreme by integrating a permanent infrastructure for collaboration into the software application.
- It adopts the strategy of Direct Activation (Wulf and Golombek, 2001) to integrate a design environment into the actual use context. However, in using an inter-weaving strategy , the solution does not require anymore that the use context must be defined by a designer. Instead, the implementation can also be calculated in the use context in a heuristic manner via dynamic reflection (Kiczales et al., 1991) of the actual system state.
- It adopts from Mørch and Mehandjiev (2000) the idea of visual components (also called Application Units) as mediators between designers and users. However, in their original work the mediation role was conceptualized as one-way communication without any feedback mechanisms. The Appropriation Infrastructure broadens Mørch's work by integrating a general communication infrastructure which connects the local context with a global product community. In such situations, the artifact present-at-hand serves as a boundary object (Fischer, 1999, Arias and Fischer, 2000).
- It adopts the idea of Use Discourse Infrastructures suggested by Pipek (2005a), but takes a closer look on the different kinds of social practice during which an artifact becomes a discourse object. The analysis reveals that an Appropriation Infrastructure should support a private interaction with the artifact present-at-hand, as well as a collaborative reflection in private and public communities. This analytical result

guides my constructional research on design of a communication infrastructure which supports these different social practices.

Last but not least, in the combination of existing conceptions a new quality emerges, so that it is justified to talk about Appropriation Infrastructure as an inherently new design methodology, created to interweave an infrastructure for situated development into local contexts of routinized work, which are mediated by the artifact present-at-hand.

1.2 Research approach: Reflective technology development

"The best way to predict the future is to invent it" Alan Kay

"The owl of Minerva spreads its wings only with the falling of the dusk" G.W.F. Hegel

My research on mediating distributed evolution follows two ambitions, an analytical and a constructional research one. These two ambitions are related, but not directly reducible to one another. The constructional ambition to support the mediation of distributed evolution belongs to the sphere of praxis, while the analytical ambition to understand the mediation of distributed evolution belongs to the sphere of theory. Both spheres, theory and praxis, are autonomous in following their own logic (see also Oevermann, 2000, Pilz, 2007). In particular, praxis can solve its affairs without an appropriate theoretical understanding, and the contribution of theory might be to alert to new problems of which praxis had not yet been aware of. This raises the general question of how to link practical and theoretical research.

In design research, the relation between theory and praxis becomes even more complex, because it is one of the obligations for researchers to produce artifacts that change the field of research in a sustainable manner. This is nothing which has to be prevented, on the contrary, inventing the future is an essential part of constructional research. The methodological fundaments should therefore reflect the issue that *inventing* and *explaining* must not fall together, and that *invention by inventing* is an essential part of design research. Typically, concepts in design research reach their full elaboration only from retrospective theoretical reflection on the object which emerged in practice. An example of this fact is given by Kuutti (1996, p. 18), who mentions that forms of "direct manipulation" are used in practice as early as the 1960's, while the owl of Minerva spread its wings only with the falling of the dusk of the 1980's, when Hutchins et al. (1986) published their theoretical work on this practice and invented "direct manipulation" as a theoretical concept. It took therefore at least twenty years from *direct manipulation* as method used in practice to *direct manipulation* as a theoretical concept for explaining the rationale of a phenomenon that had emerged in practice.

An approach that focuses on the special relation between practical intervention and theoretical reflection is Business Ethnography (BE), which was mainly developed by Bernhard Nett (cf. Nett and Stevens, 2008, Rohde et al., 2009). One of the fundamentals of BE is to acknowledge the historic contingencies of social practices which are developed in the dialectic of realization and appropriation of artifacts. The BE therefore take the results of appropriation research seriously, which demonstrate that novel practices and artifacts often emerge in the progress of invention projects (e.g. Orlikowski and Hofman, 1997, Pipek and Wulf, 1999).

Business Ethnography presents an action-research approach which is critical in its theoretical orientation and participative in its practical ambition. In its critical stance, BE studies the particular quality of everyday work practices not as a static entity, but in its development potential. The participatory aim of the BE is to support the client in her competence for self-organized development.

Business Ethnography understands development as an evolution of practices confronts an open future, which is accompanied by a non-standardizable learning process. The methodological consequence drawn by BE is that rigor in such cases cannot be reached by means of a 'hypothesis testing' -methodology[5]. The argument is that the new qualities of novel phenomena which emerged in the research project cannot be ascertained if they are subsumed under pre-defined categories. Instead, the categories have to be abducted from the emergent object itself. In such cases, it is by making abductive rather than deductive reasoning explicit that rigor is achieved.[6] Objective Hermeneutic as well as Grounded Theory (cf. Strauss, 1987, Strübing, 2008) have drawn from this the consequence that qualitative empirical research should therefore rest on an abductive methodology.

An important part of BE is the concept of *reflective technology development,* which can be used to characterize a design research approach. In his classification of design research approaches, Frayling (1993) distinguishes between 'research about design', 'research for design' and 'research through design' approach. The BE falls into the last category. Research through design Action Research approaches where "[the] subject matter [of the research project is …] observed and engaged through design, both in design thinking and in design process" (Ludvigsen, 2006, p. 15). Designers and researchers are directly involved

[5] In this point, BE differs from other Action Research approaches like Canonical Action Research (CAR) (Davison et al., 2004), which is based on hypothesis-testing methodology.

[6] Making abductive reasoning explicit marks a transition from abduction as an organic form of reasoning in reaction to a surprising fact to abduction as a controlled form of reasoning presenting a best explanation.

in such Action Research projects (see also Jonas, 2004). In addition, BE argues - not just from an ethical, but also from an epistemic point of view - that agents affected by the design should be systematically included in the research project.

As mentioned, technology appropriation is not just a mechanical action, but an essential activity in technology development. A consequence drawn from the *reflective technology development* is that *to work on the artifact* and *working with the artifact* should be two integral elements of a design research project.

Software development is a moving target, also because it is embedded in the development of practices in the flow of an open future. Therefore design research should follow an 'agile' approach. The concept of *reflective technology development* implements this demand by combining methods of agile software development with methods of agile theory building. The leads to a technique of continuous reflection on the practical experiences gained during the progress of the participatory research project. In particular, the design research project is carried out along three independent, but related threads:

- observing technology in use (*working with the artifact*)
- developing technology in reflective action (*working on the artifact*)
- building grounded theories (*working on the concepts)*

Since the logic inherent to each of the threads is different, a design research project must carry out the three threads in parallel. However, the knowledge gained in one thread can inform work in another thread (see Figure 1). This is the chosen strategy in BE to combine theory and praxis without denying the autonomy of the different spheres.

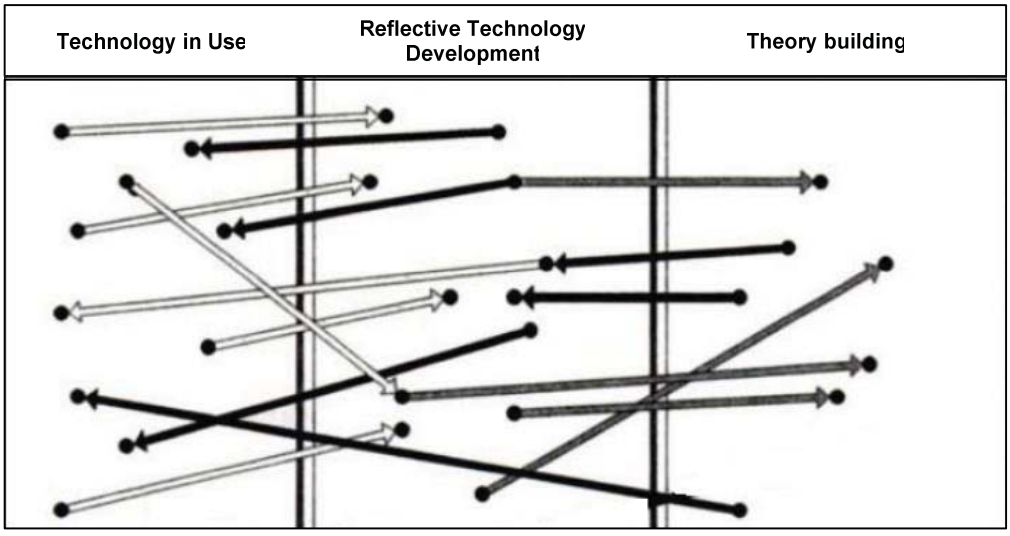

Figure 1 Phases of research conceptualized by a Business Ethnography approach, as a continuous and parallel process of observing technology in use, developing technology in reflective action and building corresponding theories, (conception adapted from Grounded Theory (cf. Strübing, 2008, fig. 1).

In methodology and method, Business Ethnography has a strong affinity to Grounded Theory. Methodologically, the affinity is given by the fact that both share the abductive stance of Pragmatism in building theories about general rationality up from the ground of the practical experience made in a research project. In method, the affinity is given by the fact that both draw a similar conclusion from the evolutionary stance of Pragmatism, arguing for the organization of research as parallel activities of theory building and practical action (see also Strübing, 2008, pp. 14). Because of the close affinity to Grounded Theory, the concept of reflective technology development can also be characterized as a Grounded Design research approach.

In my thesis, I apply the concept of reflective technology development. In particular, I organize the design research on the concept of Appropriation Infrastructure by parallel activities as indicated in Figure 1. However, I do not adapt Grounded Theory, but am using the Objective Hermeneutic as the methodological fundament for my analytical research.[7] The parallelization of the three threads is carried out as follows:

The reflective development of Appropriation Infrastructure occurred during an open source project called BSCWeasel, which was carried out in an Action Research manner. In this application, several features of Appropriation Infrastructure are integrated (see Chapter 5). On the one hand, the design work was linked with studying the technology in use through the diffusion of the BSCWeasel in two research groups (see Chapter 6), where several people regularly used the application and the Appropriation Infrastructure in their daily life. On the other hand, the design work was linked with theoretical reflection on the design concept and analysis of appropriation phenomena (see Chapter 4). The theoretical reflection of the concept and analysis of the appropriation combined uncovered phenomena which could not have been taken into account in the initial design conception. Examples of this are the cannibalization of meta-communication features provided by community help and community design systems, or the difficulties of articulating breakdown situations in a public place. In particular, theoretical reflection could uncover the quality transition as it happened by making a situated breakdown accountable in public discourse, and sensitized me to the importance of such phenomena for mediating distributed appropriation and participation.

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[7] A profound and systematic introduction into the methodology of Objective Hermeneutic and its theoretical background is given by Pilz (2007). A compact description of the corresponding interpretation technique of the Objective Hermeneutic - the Sequence Analysis - is given by Wernet (2009). In his consideration of a clinical sociology, Oevermann (2002) gives an outline of the contribution of Objective Hermeneutic to single case specific action research.

In IS research, I found some interesting attempts to uncover the underlying structure of the phenomena which popped up so unpredictably at first. However I must further elaborate these attempts, so that I can analyze the mediation mechanisms which are used in making wicked situations accountable.

The existing concepts suggested in core IT-research cover some aspects of this issue, but do not explicate the constitutive structure of situated development in the required detail. Hence, I started to adapt relevant philosophical concepts from general theories which adequately describe forms of situated evolutionary processes. For this case, it seemed useful to adapt Pragmatism and dialectic materialism, so as to arrive at a theoretical outlook which can consider general questions of scientific method and the context of economic production with the same methodological rigor it applies in examining the micro-processes of software design and use, especially the interaction of logical and spoken languages, and the complex interweaving of person and thing that surrounds the use of commodification of products. Making use of the principle of embodiment (Taylor, 1977) as a mediation concept, it was possible to elaborate a revised model of boundary objects which could determine more precisely the role of the artifact in the mediation of emerging objects (see Chapter 4). This theoretical work shapes the re-conceptualization of the initial concept of Appropriation Infrastructure (see Chapter 5).

In this sense, my analytical and my constructional research stand in a dialectical relation, where one is medium and outcome of the other.

1.3 Theoretical objective: Appropriation in distributed evolution

“I wouldn’t use PaDU [a tool for user driven innovation] to tell people about that, to say, hey why don’t you use my skin. […] Once I think this is for the general public, an aspect of design that’s interesting for all, then I would use it” Transcript taken from an interview with a PaDU user.

My abductive theory building is grounded in examples of public articulations of situated innovations which are found in the appropriation and realization of artifacts. The above transcript excerpt from a PaDU user as well as the users’ participation on the open Eclipse development mentioned in Section 1.2 are examples of such articulations. In Stevens et al.(2008), I also present a case where I analyze the reflective action of a breakdown situation which occurred in the use of a software application.

A general issue which manifests itself in the examples, and which stands in need of explanation is how new objects emerge in praxis, and subsequently gain a general interest.

Studying this topic, it becomes evident that the mediating role of the artifact cannot be separated from certain faculties of man in appropriating and realizing emergence.

Methodologically, the theory building is based in a reconstruction-logical analysis, where I begin from the existence of an (surprising) phenomenon and abduct retrospectively about necessary conditions for its possibility and the structure of mediation which occurred respectively. Such a retrospective analysis allows to reveal the constitutive structure of phenomena, which in their generality are beyond the scope of my thesis. Instead, I focus on the mediating role of the artifact that becomes present-at-hand. This leads to a theory of expressive boundary objects that is grounded in and refers to the practical problems to support user innovations and the integration of such situated development in the ongoing cycle of production.

In reconstructing the connection between the object emerging in situated actions and the related object of a public discourse, we can identify the following stages of evolution in which mediation becomes relevant:

- **On the generalizability of situated innovation**

One phenomenon that needs an explanation is how emergent objects become of general interest. Corresponding to this issue is the transition of the artifact where it becomes a common object, mediating the interest of different parties.

- **On the communicability of situated innovation**

A second issue that needs an explanation is how to communicate about an emergent object, using existing concepts without liquidating the innovative element. Corresponding to this issue is the transition of the artifact where it becomes an indexical object, mediating between concepts and actual experiences.

- **On the experiencability of situated innovation**

A third issue that needs an explanation is how foreign emergent objects can appear in one's own reality construction. Corresponding to this issue is the transition of the artifact where it becomes present at-hand, mediating between an own and a foreign reality.

This brief reflection about the constitutive structure of my research objects gives a first outline of the demands that an adequate theoretical foundation should address. The reflection also indicates that a theoretical foundation would benefit from a conceptual synthesis of situated sensuality and common sociality.

In my abductive theory building, I study the public articulation from the perspective of crisis, in its innovative potential of being a *creative destruction* of the existing (see also Stevens et al., 2008, Stevens et al., 2009b). Fortunately, crises are and should be an exceptional case

in practice (see also Pipek and Syrjänen, 2006). This might raise the objection, why to ground theory building about distributed evolution in the exceptional case of crisis and mediating emergent objects. In support of this approach, I follow Oevermann's (1991, 1996, 2001b, 2008b) argumentation that a theoretical foundation should not rely on the normal case of routines, but should rest on crisis as the exemplary case. The key argument for this position is that the mediation in question is 'out of order' in routinized action, because routines can take advantage of solutions that are born in crisis. This is different from the case when the emergent object does not exist, but has to be realized and/or be appropriated in situated action. In the public articulation of emergence (either in making a breakdown accountable or in articulating a situated innovation), the diverse mediation mechanisms become necessary and therefore analyzable.

A grounded theory that rests on the normal case of routinized action must treat them as black boxes. Such a strategy would therefore not lead to an adequate theoretical foundation for the constitution of structure of distributed evolution, where emergence is always a latent option.

In searching for an appropriate theoretical foundation for discovering the constitutive structure of the phenomena in question, I found several links to existing theoretical concepts in IS research. To my best knowledge, the most relevant are

- the concept of structuration of technology, developed in the non-positivistic stream of innovation research in IS (Poole and De Sanctis, 1992, Poole and De Sanctis, 1989, Orlikowski, 1992, Orlikowski, 2000),
- the concept of situated actions, developed in the research area of Computer Supported Cooperative Work (CSCW) (Suchman, 1987)
- the concept of the boundary object, developed in the area of Science and Technology Studies (STS) (Star and Griesemer, 1989, Star, 1990) and
- the Activity Theory as a framework of research on Human Computer Interaction (HCI) (Kuutti, 1996, Kaptelinin and Nardi, 2006).

All these concepts provide important insights into mediating situated innovations, but none explicate the constitutive structure of the observed phenomena in any detail. Therefore, I took a closer look at the philosophical roots of these conceptions, which rely mainly on the anti-Cartesian work of Marx, Mead and Wittgenstein. In particular, in studying the deeper philosophical roots, I found a solution for the subject matter of mediating the emerging object in praxis in the Romantic work of Marx (cf. Honneth, 1995) and Mead (cf. Zehentreiter,

2006), while Hegel (cf. Westphal, 2003, Taylor, 1977) and Peirce helped me understand the general logic of mediation structures.

The related philosophical considerations rest on an evolutionary, expressive thinking that takes the existing of emergence and progressive development for granted, and uses this as a starting point for philosophical inquiry which explores the necessary constitution of man to produce and/or become aware of emergence in progressive development (I also use the term innovation within this context). Generally speaking, the constitutive elements of the subjective side are mainly given by the existence of *genuine doubt* or *objective contradiction* in praxis as a source for and the existence of *semiotic* or *dialectic* mediation as a means of (knowledge) development. On the objective side, constitutive elements are mainly given by the existence of a general expressive nature that appears within the manifold of the present.

In the following, I clarify my theoretical position in the critical examination of related work in IS research. I use this general examination of related work also to introduce some central ideas of Romantic Expressivism, and the way these ideas are transformed in history. Unfortunately, I can only introduce these ideas in their barest essentials, while a full-scale exposition in its necessary complexity is beyond the scope of my thesis. The explication of the underlying grand theories mainly serves as a problem-framing strategy to become aware of the general problematic of mediating fragmented development, shaping the analytic lens and sensitizing the empirical observation.

The first candidate for a theoretical foundation is the innovation research in IS. The dominant stream of this research rests on a quantitative, positivistic stance. A literature survey of the research that follows the positivistic paradigm is given by Fichman (2004). The key aim of this paradigm is to find the relevant factors that cause the diffusion of innovation and adoption behavior in social systems. However, in studying innovation processes only from a quantitative side, it neglects its qualitative side. In particular, it discusses not the transformation of subject and object in progressive evolution and related mediation instances. The dominant paradigm therefore does not provide the appropriate theoretic lens for exploring my research object.[8]

The picture is different in the case of innovation research approaches that are based on adaptations of Giddens' structuration theory (cf. Jones and Karsten, 2008, Pozzebon and Pinsonneault, 2001), which are classified by Fichman (2004) as non-positivistic approaches of innovation research in IS. In respect to a theoretic foundation of situated innovations the

[8] I discuss this topic in more detail in Stevens et al. (2009b) and Pipek, Stevens et al. (2008).

work of De Sanctis and Poole and of Orlikowski are the most relevant. Orlikowski (cf. Orlikowski, 1992, Orlikowski and Robey, 1991, Orlikowski, 2000) as well as De Sanctis and Poole (cf. Poole and De Sanctis, 1989, Poole and De Sanctis, 1992, De Sanctis and Poole, 1994) present mutually independent theoretical models of technology structuration, yet both rely heavily on Giddens' conception of structuration as a duality of being both medium and outcome at once. The authors adapt the key idea of structuration to explore the constitutive structure of technology and the relationships between information technology, agency, and social structure.

One of the merits of the adaptation of Giddens is to link the structuration of technology conceptually with the structuration of society. In doing this, it becomes evident that research on the constitutive structure of technology cannot be done without revealing the constitutive structure of agency, based on Giddens' (1984) insight that

> "[t]he constitution of agency and structure are not two independent given sets of phenomena, a dualism, but represent a duality." (p. 24)

The research on the structuration of technology does not develop its own concept of agency, but follows Giddens (1984) definition. He characterized agency as the *capacity to make a difference,* being able to '*act otherwise*'. By virtue of this competency, the use of technology cannot be reduced to a causal relation. However, one important source for misunderstandings in the literature arises from overlooking that agency in Giddens work is not an empirical, but an analytic (or more precisely', a constitution-theoretical) category (Jones and Karsten, 2008). As an analytical category, Giddens emphasizes the logical connections between freedom, power and agency as mutually constitutive:

> "Power and freedom in human society are not opposites; on the contrary, power is rooted in the very nature of human agency, and thus in the 'freedom to act otherwise'" (Giddens, 1995, p. 4).

The distinguishing feature in the adaptation of Giddens by Orlikowski and De Sanctis and Poole concerns the question whether structure is embodied in technology, or whether it is a phenomenon that emerges from using technology. This leads to the question of how to frame appropriation conceptually. Following Orlikowski (2000), the work of De Sanctis and Poole rests on a 'structure is embodied in technology' -view. The picture drawn by the authors is that designers embed structure (consciously or unconsciously) within technology, and that users appropriate structure during their use of the technology:

> "Designers incorporate some of these structures into the technology […] Once completed, the technology presents an array of social structures for possible use" (De Sanctis and Poole, 1994, p. 125).

Criticizing this picture, Orlikowski elaborates her own position which rests on a “structure is enacted to technology” -view. Reversing the picture drawn by De Sanctis and Poole, she argues that the action of users “enacts emergent structures through recurrent interaction with the technology at hand” (Orlikowski and Iacono, 2000, p. 407). Orlikowski as well as Jones and Karsten (2008) argue that the introduction of the appropriation concept is responsible for the shortcomings in the work of De Sanctis and Poole. In the following, I will draw a more differentiated picture of the concept of appropriation and its adaptation by De Sanctis and Poole.

Giddens elaborates the constitution-theoretical understanding of agency in his work on the constitution of society, where he does not, however, elaborate on an explicit notion of technology. That was one of the reasons why De Sanctis and Poole (1989) suggest a conceptual synthesis of Giddens’ concept of *structuration* and Marx’s concept of *appropriation.* They adapt the Marxian concept of appropriation as the “key that unlocked the nature of subject-object relationships” (Poole and De Sanctis, 1989, p. 150). The essential conclusion that De Sanctis and Poole draw from conceptual synthesis is: *Technology presents a specific form of structure that is outcome and mediator of human action. It does not determine action directly, but has to be appropriated by the agents. In particular, technology in use cannot be reduced to a causal relationship without running in contradiction to the constitution of structure and agency.*

Poole and De Sanctis integrate ideas coming from Hegel, Marx and Mead to uncover the constitution of technology . This is quite close to my strategy of using these grand theories to figure out the fundamental constitutive structure of emerging objects which appeared in situated actions mediated by the artifact present-at-hand. Therefore, I present the early work of Poole and De Sanctis in more detail. This makes it also possible to introduce the philosophical background of the concept of appropriation, which is based on the Romantic roots of Marx emphatic understanding of labor.

In the discussion of the work of Poole and De Sanctis, I also show where and how I chose my separate ways in subsequent theory building. In a nutshell, Poole and De Sanctis integrate the concept of appropriation in a positivistic theory conception, while I integrate it into an analytic theory conception which I then use to work out the mediation structures embodied in the artifacts present-at-hand.

In reflecting the philosophical roots of appropriation, one has to first of all state that in Marx’s theory, the concept of appropriation cannot be separated from the concept of realization. Both are mutually constitutive elements which are embedded in and mediated by the

dialectic unity of human labor. The 'freedom to act otherwise', as put forward by Giddens, plays an essential feature in both moments of the dialectic unity of labor. The first moment is the freedom in appropriation, which describes the competence to construct meaningful reality differently (the power of utopian thinking).[9] The second moment is the freedom in realization, which describes the competence to change the construction of material reality (the power of utopian practice).

Marx emphatic concept of labor refers to the productive and self-constructing nature of humanity. In this point, Marx's philosophy is influenced via Hegel from a Romantic expressive anthropology:

> "[Marx] understood human labour not only as a productive achievement, but as a formative event as well. […] In doing so, he was guided, via Hegel, by the central motifs of that expressive anthropology which can be considered the main achievement of the Romantic wing of the German Enlightenment, dating back to Herder" (Honneth, 1995, p. 9).

The central idea of expressive, evolutionary anthropology is rooted in the notion that in opposite to the animal, man abandons the nexus of immediateness.

By virtue of this act, man becomes a natural and rational being at the same time which posits the universality of a species being: "Man is a species being, […] because he treats himself as a *universal* and therefore free being" (Marx, 2007, p. 90). However, at the same time the freedom to be a universal being also separates man from nature, both outside and within. In other words, the competency of man to have *freedom to act otherwise* is therefore inevitable linked to *personal alienation*, yet the moment of alienation cannot be overcome in a true sense by returning to a previous state. Instead, the separation of man and nature should be sublated in a Hegelian sense[10] in the ideal that the human (both as individual and as genus) recognizes his being in nature while expressing himself in and as nature. The

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[9] The term meaningful construction of the social artefact is adopted from Schütz's "Der sinnhafte Aufbau der sozialen Welt", which is literally translated as "the meaningful construction of the social world" (cf. Schütz, 1967, p. xvi).

[10] Sublation (Aufhebung) is a fundamental concept in Hegel's logic. It is given by the synthesis of a concept and its contradiction. A sublation has a twofold character given by the two meanings of *aufheben* (sublate) in German, namely "to cancel or nullify" and "to preserve, and to raise up". Hegel's method of sublation is "to identify and nullify their errors while preserving the insights of view […] by incorporating those insights, suitable revised, within a more sophisticated and adequate view" (Westphal, 2003, p. 16). This means on the one side the old is cancelled by the new. On the other side, the old is kept within the new, so that it can be reconstructed from the level of the synthesis. The concept of sublation is closely related to the concept of evolution in the flow of an open future, where history is given by the sublation of the past in its twofold character.

expressive nature is therefore both, a mode of world disclosure (*Welterschliessung)* and of authentic self-expression in the Romantic sense:

> ”[O]ur life is seen as self-expression also in the sense of clarifying what we are. This clarification awaits recognition by a subject, and man as a conscious being achieves his highest point when he recognizes his own life as an adequate, a true expression of what he *potentially* is - just as an artist or writer reaches his goal in recognizing his work as a fully adequate expression of what he wanted to say. And in one case as in the other, the ‘message’ could not have been known before it was expressed. […] The specific property of human life is to culminate in self-awareness through expression” (Taylor, 1977, p. 17).

In Romantic thinking, the expressive nature was mainly conceived from the perspective of personal self-development. Arts were considered to be the primary realm for this form of life (cf. Taylor, 1977, p. 17), providing a blueprint of the Romantic ideal of life to realize oneself by means of authentic self-expression.

The Romantic ideal emphasized the formation of man in the process of expression. By contrast, current theories rely on a conduit metaphor of communication (Reddy, 1979) as a self-evident interpretation scheme (cf. Stevens et al., 2009b). In this interpretation scheme, the material artifact is reduced to its role of carrying the antecedently given intention of the producer. A prominent design theory that rests on a conduit metaphor is Cognitive Engineering (CE) (Norman, 1986), which presumes that a prefabricated mental model exists in the head of the designer, which just needs to be translated into a material artifact. Another prominent example is the Diffusion of Innovation (DOI theory) . CE has overly voluntaristic perspectives on the production of a message, while DOI has overly deterministic perspectives on the adoption of message. Therefore, it seems that they are opposing theories that stand on the different ends of a continuum. However, what both have in common is that they both are mechanistic models that ignore the moment of situated innovation given by expressive nature. Against the backdrop of common interpretation schemes in research on production, diffusion and adoption of innovation, it cannot be over-stated that expressive anthropology is elaborated from a paradigmatic case where the *‘intention of the artifact’ could not have been known before it was expressed*.

In reception of the expressive concept of man, Hegel and Marx introduce two important transformations that hang onto the essential idea, but adapt it to the specific conditions of an industrial society. The first transformation was carried out by Hegel who took up this idea for his conception of work which Taylor (1977) characterizes as follows:

> “At the same time man in acting on external nature to serve his purposes, in working, helps to transform it and himself, and to bring both sides towards the eventual reconciliation” (p. 120).

This concept places crucial importance on work as human self-positing. In particular, Taylor perceives in the expressive nature the option to sublate the separation of man as a natural being and man as a rational being. His aim was to reconcile man and nature by the ideal of a well-done expression: *A well-done expression overcomes the contradiction of the subject's intent and object's constraints, re-defining on a higher level of freedom through the capacity of understanding the necessity*. The theory of Expressivism is therefore closely related to an empathic understanding of praxis and human action in creative situations. In particular, not only the human actor is considered creative, but the situation itself has a creative quality, transforming nature according to its own intent, but also transforming the self in the appropriation of an expressive nature. Marx appropriates the dialectic of self-expression in and through nature. In Romantic thinking, the idea culminates in the motive of the genius. In contrast, Marx transformed the essential idea into a mundane variant by considering the conditions of economic production in capitalism. In doing so, he adopts the pre-industrial, in part elitist ideals of Romanticism, and generalizes them to any kind of labor. This line of thinking culminates in the motive of objectification of labor: *Man is constituted by labor as the realization of man in nature through the appropriation of nature. Products, as results of labor being expressive artifacts, can be analyzed from the normative ideal of objectification of labor as well-done expression of man in nature.*

The brief explication of the historic-philosophical background demonstrates that De Sanctis and Poole's synthesis does not attempt to amalgamate two disparate concepts. Instead, the analytical understanding of human action in expressive anthropology provides a key to unlock the nature of the subject-object relationship which is closely related to Giddens' understanding of agency mentioned above. From the analytical (not empirical!) perspective, the constitutive act of man to step out of the nexus of immediate action describes a paradigmatic example for studying the concept of agency as a meaningful behavior.

The expressive anthropology thus provides an outline of the analytical framework with which to address the phenomena of technology in use as an open process, and to explore the mediation of emergence in situated innovation. In particular, exploring ontological assumptions of paradigmatic examples would lead us to a dialectical three world conception, which sheds light on the relevant mediation mechanism in realizing and appropriating emergent objects in situated innovations: The specific quality of the evolution of expressive artifacts emerges from the fact that logically, the constitution of man as a universal being is connected to the constitution of three worlds. The three worlds can be characterized as the

world of material objects, the world of meaningful objects and the world of objects present-at-hand (or expressive objects).

Reducing the meaningful reality to the material, or inversely, reducing the material reality to the meaningful one would lead to a dualistic technology conception, with limitations imposed by overly deterministic or overly voluntaristic perspectives (Orlikowski, 1992). However, if one wants to prevent these shortcomings, the challenge to be answered by non-reductionistic theories is how to mediate between material and meaningful reality.

The argumentative path taken by expressive anthropology is informed by the dual citizenship of man, being a member of material and of meaningful reality. Both worlds relate to each other by means of mediation of a synthesizing practice, but are categorically not directly convertible into one another. In particular, synthesizing practice presumes the existence of expressive objects living the boundary area of material and meaningful world. These expressive objects cannot be reduced to either material or meaningful object, instead they have the own (ephemeral) identity as well as creative potential in affecting both material and meaningful reality.

The constitution of the human as living the three worlds also has implications for the constitution of technology as human product. While it is meaningless to ask for the purpose of a stone or a software artifact in any physical or metaphysical sense, this is different in the case of technological objects. Although the physical form might not change, in the socialization of a stone as a tool, the object will change its character. It becomes a natural and rational being at the same time. Technology is therefore constituted by the dialectic unity of material and meaningfully constructed reality, as mediated by an expressive nature.

The contradiction between material and meaningful construction is mediated by the expressive object as embodied in the artifact present-at-hand. More precisely, in the situation when artifacts become present-at-hand, the corresponding expressive object has a boundary quality which connects the symbolic and material construction of the artifact in question, yet is robust enough to maintain its own identity in the evolution of the dialectic unity.

In this sense, the expressive object becomes the site of situated innovations, where the opposition of embedded and emergent structure leads to a false dichotomy. Instead, the appropriation of the embedded structures provides the needed material for the realization of emergent structure, where

> "[man] confronts the materials of nature as a force of nature [… and by] acting on the external world and changing it, he at the same time changes his own nature" (Marx, 1992, p. 283).

Having worked out the origins of the appropriation concept, I can clarify more precisely similarities and differences between my theoretical position and the work of De Sanctis and Poole. Their theoretical model is based on the assumption that the designer incorporates an array of options into technology, and in an open process of appropriation, the user utilizes this incorporated structure for her own purposes.

With regard to this model, I share the view of De Sanctis and Poole that appropriation is an inherently open process that is insufficiently recognized by the Technology Determinism point of view. I also agree that analytically, the concept of structure embodied in technology is a constitutive element for appropriation, also because it provides the material of nature which has to be used constructively. However, the situation of appropriation is given by a manifold of possibilities which cannot be reduced to discrete sets of pre-described options that are incorporated by the designer. Moreover, it is questionable whether De Sanctis and Poole's view is an appropriate conceptualization to describe the innovative character contained by the basic duality of technology.

The reductionistic tendency in the work of De Sanctis and Poole is closely related to their positivistic research interest, which is to formulate a predictive theory of technology use.[11] From a positivistic stance, the key innovation of Adaptive Structuration Theory (AST) is the fact that the openness of structuration processes is taken into account, the lack of which was a major drawback of Technology Determinism. De Sanctis and Poole overcome inconsistencies of previous theories by integrating the outcomes of appropriation processes into their theory building. However, in order to formulate predictive hypotheses, the authors are forced to introduce a binary measure of faithful or ironical appropriation. Moreover, in order to operationalize this measure, they are forced to interpret 'spirit' and 'appropriation' as empirical categories, which leads to a problematic reification of Giddens' analytical constructs which is critically discussed by Jones (Jones, 1999, cf. Jones and Karsten, 2008). On a theoretical level, this reduces the openness of appropriation and structuration to a choice between two alternatives. As a result of their theory concept, De Sanctis and Poole study the constructive moment in appropriation only from the upstream perspective of <u>what has been selected</u> and not from a downstream perspective <u>what is constructed</u> out of the material provided by the embodied structure of the technology in question. In opposite to this, a

[11] Giddens work must not necessarily be adapted from a positivistic stance. For example Orlikowski (2000) uses Giddens' theory of structuration from an interpretative stance. It also seems that many differences in the various adaptations of Giddens in IS (cf. Pozzebon and Pinsonneault, 2001, Jones and Karsten, 2008) are based on differences in the underlying theoretical model of science.

non-reductionistic position should not only look downstream to the conditions of action, but also upstream at the products of action in their own quality. Such a theoretical position is needed to uncover the constitutive structure of situated innovation, and related to this, to arrive at an understanding of the mediation mechanisms needed to articulate situated development in distributed evolution.

I use the view of appropriation as an expression of a life practice, to clarify the difference in the views: In working out the Advanced Structuration Theory, De Sanctis and Poole hamstring the possibilities for an subject to express themselves, so that one has only the binary choice to appropriate technology either ironically or faithfully. In contrast, I am interested in the expression regarding potential to produce a situated innovation, where neither ironic or faithful presents the appropriate category to classify the emerging practice.

The theory building by De Sanctis and Poole that rests on the concept of appropriation follows the agenda of the positivistic innovation research paradigm mentioned above. For the same reasons as articulated against the positivistic paradigm, this part of De Sanctis' and Poole's work has lost its relevance for the study of mediating situated innovation. At this point, the practice lens of Orlikowski (2000) becomes relevant. She looks from the downstream perspective of the products of situated development, focusing on the emergent structures that have developed in recurrent interaction with the technology at hand.

However reverting, instead of transforming De Sanctis and Poole work, Orlikowski reproduce the dualistic conception with reversed signs. This position implies the danger of falling back into a voluntaristic position. To overcome a false dichotomy of embedded versus emergent, I suggest not to drop the concept of appropriation as suggested by Orlikowski (2000), but to take the dialectic origins of that concept seriously. In this view embedded and emergent are mutually constitutive for the appropriation of technology confront an open future. Therefore, situated development should be studied from an upstream perspective on the condition of action (embedded structure) as well as from a downstream perspective on the production of action (emergent structure).

In summary, the IS interpretation of structuration theory presents an important step for explicating the constitutive structure of technology in its co-evolutionary character. In particular, in the conceptual synthesis of structuration and appropriation lies a remarkable attempt to uncover the mediation structure regarding the possibility of situated innovation. However, such an attempt needs to take the expressive origin of the appropriation concept more seriously into account to prevent a reductionistic view on the research object.

The second candidate for theoretical foundation is Activity Theory, which becomes a prominent framework in research on human-computer interaction. Activity Theory is a psychological theory that is going back to the work of Vygotsky, Leontiev and Luria (cf. Kuutti, 1996). As a psychological theory, it gets its own flavor from the fact that it does not take the individual subject as the starting point from which to deduce the main theoretical construct. Instead, Activity Theory argues that theory building has to rely on praxis as its primary category. In this point, Activity Theory is influenced by the work of Marx. In addition, the elaboration of the fundamental concept of activity (and the idea of an activity system) presents an adaptation of the dialectic notion of labor. In sharing the common philosophical background, my theoretical position is often close to the theoretic considerations elaborated in Activity Theory. However, my work is not explicitly activity theoretical. I focus more strongly on the constitutive structure of mediating emergence and the dialectical character of appropriation.

The third candidate for a theoretical foundation is the conception of situated action by Suchman (1987), which becomes a mainstream position in CSCW. Her work provides an excellent critique of a calculus-based foundation of action as suggested by the paradigm of Artificial Intelligence (see also Stevens and Wulf, 2009). However, in applying the concept of plans and situated actions to uncover the structure of situated innovation, the problem arises of how to conceptualize the development (and in the limit case the emergence) of plans. This topic was not addressed by Suchman, which is why I had to enlarge the concept at this point. In order to prevent an idiosyncratic theoretical model, I decided to re-interpret the concept in terms of the Romantic idea of expression. From this point of view, the paradigmatic case is given when *'the plan could not have been known before it was expressed in a situated action'*. This makes it emphatically evident that plans do not refer to the mental mechanisms that drive action, but in the tradition of Wittgenstein, are a means to give action a meaning.[12] In particular, it demonstrates that situated actions are not just the site for realizing plans, but also the site for appropriating plans. Situated actions are therefore productive and formative at the same time. In particular, in this Romantic view of situated actions, the emergent objects that appear in action contain a seed for new plans (and this means also, for a new form of rationality). Moreover, a situated action can neither be reduced to a reality of plans, nor to the ephemeral reality of situatedness. Therefore, a situated action must mediate in some sense between the ephemeral and the structured reality

[12] Of course they must be in some way connected with action to make sense, however this is no causal, but (in some sense) a semiotic relation.

to save the emerging quality of a new rationality. This mediation quality of an expressive situation is grounded in life practices, and presents on a very fundamental level the constitutive structure of situated innovations. I call the mediation structure embodied by situated actions also the expressive or situated boundary object.[13] The existence of such a situated mediating structure is postulated mainly for theoretical reasons, to explain the possibility of innovations. Introspectively, we get at best an impression of the ephemeral moments in breakdown situations, in which a situated boundary object itself comes to consciousness in the form of a contradictory experience.

In summary, Suchman shows the essential role of situatedness for human action. In my theoretical model of appropriation, I follow Suchman in this point. However, the concept is insufficient to uncover the constitutive structure of situated innovation, as it has no explicit theoretical concept of the development of plans. Therefore, I re-interpret the concept of situatedness in an expressive manner. In this view, plans (and therefore also rationality) develop in the situated actions of appropriating the world.

The fourth relevant element for a theoretical foundation of my research is the boundary object concept of Star (cf. Star and Griesemer, 1989, Star, 1990). The essential feature of boundary objects is that they are located in the boundary areas between different realities,

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[13] As demonstrated by the Activity Theory, in situated action the tool at hand mediates between subject and object. In order to fulfil this function the situated tool must belong to a subjective as well as an objective reality. The same holds for the situated action as a whole. In that sense, the situated tool and the situated action presents to different view on the same the mediation quality. To make this relationship between the different views explicit I specify mediation quality by a triadic relationship expressing the formal structure of expressive boundary objects. The first relata refers to meaningful world, the co-relata refers to material objects of the meaningful world and the third one mediates the second for the first.

At some places I state that the mediation structure is embodied in the artefact present-at-hand, but also in the situated action or in the reflection of a wicked situation. This sounds at the first glance confusing, however this just means that I reconstruct this triadic relationship from different angles.

In a similar sense, one can reconstruct the (reasoning) situation, where Newton has been abducted the law of gravity from the falling apple from different angles. For example we study the features of the apple present-at-hand to serve as a boundary object to mediate the law of gravity. In addition, we can also focus on the subject, Newton, in order to figure out why he has become a medium to translate the situated experience into a commonly accepted law, etc. Focussing on the subject, a notable case study is presented by Steiner (2004). In his work, he reconstructs the historical case of Philipp Semmelweis transforming a wicked situation to a theory about childbed fever (which now is well accepted). My thesis supplements such kind of research on mediating (knowledge) development from a product perspective, where I investigate the role of the artefact present-at-hand in finding and realizing product ideas.

and serve as a common structure to mediate between them. The work of Star provides an appropriate analytic lens to study the mediation of fragmented knowledge construction in distributed social worlds. Moreover, her work creates an awareness of the essential role of commonly structured objects to solve the theoretical puzzle of how articulation of situated innovations can be achieved in distributed consumption and production practices.

However, Star takes the existence of such shared structures between the distributed social worlds for granted. In particular, she does not explain how boundary objects can be appropriated and socialized by individual and social subjects as constituted by the social practices as a whole. A theoretical foundation to explain situated innovation in distributed evolution can therefore not be completely grounded in Star's model of the boundary object.

In order to answer the analytical problem about the appropriation of boundary objects that emerge in situated action, I also re-interpret boundary objects in terms of the Romantic idea of expression. This allows the integration of both concepts - situated actions and boundary object - in a revisited model of situated evolving boundary objects. In such a model, the theoretical limitations are fixed by integrating the static into an evolutionary view which also covers the constitutive structure which again determines how boundary objects can be appropriated. Such a revised model retains essential features of the models outlined above, yet abstracts from the specific form. By means of such a transformation, a boundary object's potential for being appropriated can be grounded in the capacity of situated actions to appropriate emerging objects. With regard to my research interest, I conceptualize such an evolutionary boundary object with a special focus on the experiencability, communicability and generalizability of situated innovations as mentioned above. From this point of view, I explore the boundary object's qualitative embodiment in the artifact present-at-hand.

In this section, I have outlined my theoretical stance. This was shaped by my research object, the public articulations of situated innovations which appear in the appropriation of software artifacts. Following the methodological considerations of Section 1.2, theoretical reflections were grounded in observations of phenomena which regularly occur in the use of appropriation infrastructures and which require explanation, like the examples provided at the beginning of this section. Such an approach guided my research endeavor which about uncovering the constitutive structure of the phenomena instead of subsuming them under a pre-defined theory. However, following an empirically grounded theoretical approach does not mean that the empirical data speak for themselves, or that one should avoid to utilize accumulated knowledge of existing theoretical constructs by making it a rule that theory must be ignored (cf. Pilz, 2007, Strübing, 2008). Yet historical hindsight and more impor-

tantly, mere logical reflection on the methodological foundations of empirical science shows that knowledge development only occurs when existing beliefs enter into dialogues with the unknown objects.

In my case, the most promising attempts to uncover the underlying structure of situated development are given by non-positivistic conceptions of information technology in use. I adapt these streams in research in the following manner:

I follow the evolutionary stance of the structuration approach in IS to explore the phenomena of technology in use. In particular, I follow the path of De Sanctis and Poole, making use of appropriation as a theoretical construct to explain the phenomena of non-intended use. However, I argue that from a non-positivistic position, one should take the origin of the concept more seriously. In doing so, I prevent a fall back into the obsolete distinction between subjectivist and objectivist conceptions of technology. This distinction reappears in the appropriation literature when discussing 'embeddeness' juxtaposing 'enactment' (cf. Orlikowski, 2000).

- I adapt from Suchman her consideration of situation as an irreducible, constitutive category of human action. However, Suchman's work lacks a concept of development. Therefore, I re-interpret the concept of situated action from expressive anthropology, so as to overcome this limitation regarding to the appropriation of the innovative potential appeared in wicked situations.[14]
- I adapt from Star her notion of boundary object as a mediating structure between different realities. However, Star did not explicate the appropriation of boundary objects, but treats this as a black box. I open this box by abstracting in a first step from the specific content, and in a second step, exploring the related forms of mediation between different realities. A third step shows the constitution-theoretical relationship between these diverse forms. This move in theory-building enables a conceptual synthesis of the sensual qualities and the social qualities of appropriation, which provide an appropriate framework for the study of situated development as a part of distributed evolution.

The above list presents the major theoretical influences which I have adapted to elaborate my Pragmatistic position that is rooted in a dialectic understanding of praxis and my under-

[14] Out of scope of my thesis, but nevertheless an interesting research question is whether the limitations in Suchman's work can be overcome in general by a systematic adaptation of Peirce's evolutionary logic (which also provides a sound critique on a calculus based conception of action, cf. Müller, 1999).

standing of artifacts as a dialectic unity of materially and meaningfully constructed objects. I then apply my revised model of boundary objects to analyze the structure of the appropriation work and especially the role of artifacts in articulating wicked situations across social worlds.

My analytical contribution elaborating a situated view on boundary objects was co-evolve with my constructional research to support the sensual and social dimension of appropriation work. In particular, interpreting expressive boundary objects in terms of designing an Appropriation Infrastructure, it became evident that the major challenges in user centered solutions for co-production are:

- to integrate the relevant, but distributed development activities in the local context of a wicked situation and
- to support the user in articulating design and use experiences facing with the specific constellation of the situation.

1.4 Outline of major concepts

In this section, I will give an outline of the major theoretical constructs of my thesis, and outline the constructional challenges which were shaped by my analytical understanding of the phenomena of appropriation in distributed evolution.

1.4.1 Dialectic constitution of artifacts

In Section 1.3, I have given a brief outline of a non-reductionistic concept of artifacts that rests on a three-world model. From this perspective, the artifact present-at-hand is a meaningful object that represents a related socio-material construction. This view of artifacts is linked to the Giddens tradition in IS research (see Section 1.3), but also related to theoretical conceptions in Participatory Design (Ehn, 1990, Bratteteig, 2003, Bjerknes et al., 1987) and Activity Theory oriented Interaction Design (cf. Kaptelinin and Nardi, 2006, Nardi, 1996).

In this section, I will elaborate the dialectic perspective which is shaped by Marx's central themes of labor and product as labor's objectified counterpart. Inherited from Romantic Expressivism, these are regarded as medium and outcome for the self-creation of man, where labor has a formative effect on the subject (as individual as well as genus) as well as a productive effect on the object (as a concrete product as well as humanized nature in general) (cf. Márkus, 1978, Röhr, 1979). Labor and its objectification evolve over time, and accumu-

late traces of their socio-historical formation processes. In such processes, the meaningfully and materially constructed reality evolves as a duality of being medium and outcome of individual and social labor. This is a co-evolutionary process by its very nature, which we can explore by thought experiments and examples.

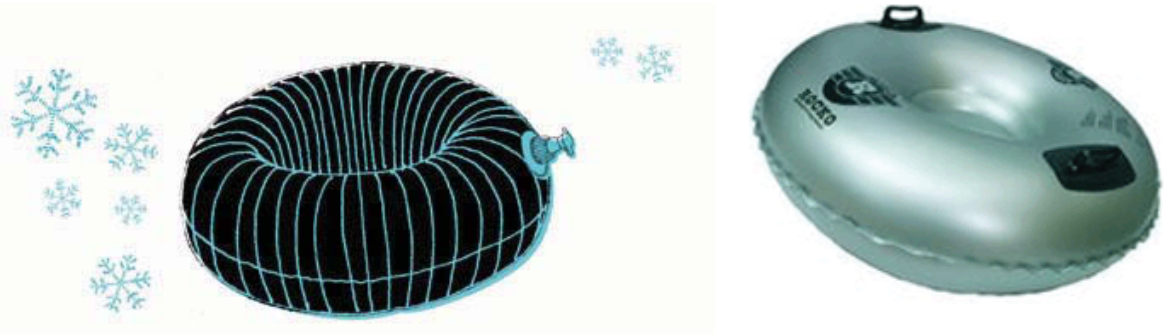

Figure 2 Co-evolution as a dialectic unity: Recognizing a car tire as a means to go sledding (left) changes the meaningful construction. A change in the meaning creates a new, but (using a Hegelian term) partially untrue artifact. In order to become a true sledge, the changed meaningful construction needs to be embodied in a changed material construction (right).

For example, we can take a look at the formation of the artifact, which is represented in Figure 1. On the one hand, we can interpret the illustrated material construction as an affordance to appropriate the object as a means to go sledding. On the other hand, we can interpret the intention to go sledding as an affordance to realize the object as a means for this intention. In both cases, we make a connection between the material and meaningful object.

Drawing a connection between the material and the meaningful reality raises the question what comes first, meaning or material. The answer to this question depends on whether one subscribes to the deterministic or the voluntaristic technology conception. The deterministic position argues that the material object, which came first, causes the intention. The voluntaristic technology model argues the other way around, that the intention came first, forming the material objects. However, as mentioned above, the dialectic conception cannot fall back into the false dualism of an exclusive choice between either a deterministic or a voluntaristic constitution of technology. Therefore, a dialectic position must find another answer to this question of what comes first. To address this question, we should distinguish between the static and the evolutionary case.

In the static case, the artifact can be abstracted from the connection, defining the artifact as given in a true realization of the intention. More precisely, in the static case, the material and meaningful objects collapse into a unity, where the material expresses the meaning and vice versa. In this case, the connection vanishes, so that the unity leaves no places from where to ask the question of what comes first.

In the evolutionary case, the artifact is given as an untrue realization of the idea, defined in terms as a contradiction. In this case, a relapse into voluntaristic and deterministic positions can be prevented by hypostatizing the contradiction into an independent entity. Doing this, a dialectic position can state that the contradiction itself comes first. It constitutes a wicked situation where the material and the meaningful object do not express each other, but co-evolve in an open manner until it overcomes the contradiction contained in the mutual expression, so that a static case is reached on a higher level.

My own dialectic position follows the concept of *situated development*. In its barest essentials, this concept can be characterized as follows: first, the artifact development is grounded in the contradiction; second, contradictions have an objective reality; third, the reality of contradictions is given by the ephemeral world of situated objects. The constitutive structure of situated objects is mainly given by two features, the first being that they have no permanent, but an ephemeral respectively evolving structure, which is why I call them situated. Secondly, they have a mediating structure which connects intentional and extensional reality, which is why I call them expressive boundary objects. Structurally, the world of situated objects can be identified with Mead's (2002) phenomenological concept of present. The present is a reality with no permanent substance, but is constituted by a "flux of '*emergent events'* which forever arise and perish in an evolving temporal process of creative advance towards novelty" (Odin, 1996, p. 229).

To argue that situated objects have no permanent substance does not mean that they do not have any real effects on permanent objects. Instead, these objects leave ontic and epistemic traces, determined by the dialectic of appropriating and realizing situated innovations (cf. Section1.3). The situated objects therefore have the strange character that in praxis we become aware of them in moments we experience as contradictory, where the artifact unexpectedly become present-at-hand, while methodologically these objects can be ascertained only in reconstruction by virtue of their remaining ontic and epistemic trace.[15]

Phenomenologically, the situated objects are given by the artifact present-at-hand emerging in wicked situations. They present cuts in the cultural-historical history of the artifact. These

[15] A methodological consequence of the theoretically postulated evolutionary structure is that the existence of such situated objects can be detected empirically only with the help of indirect proof. This thought is further elaborated by Pilz (2007) for the case of aesthetic objects. Aesthetic objects can be interpreted as a special form of situated objects (see below). They enable play with the contingent construction pleasurably, without external pressure, while the notion of situated objects covers the play of contingent construction in general (e.g. also in the case of breakdown situations, cf. Stevens et al., 2008). Although Pilz focuses on a special case, to a large extent his considerations can nevertheless be widely generalized.

cuts are located in the here-and-now, which is connected with and representative of the once-and-there. The once-and-there can be further divided into the spatio-temporal past, and the future of the artifact. Looking downstream, the artifact present-at-hand accumulates the cultural-material history of its genesis. Looking upstream, the artifact present-at-hand anticipates the cultural-material history in its development. The artifact present-at-hand is therefore neither an entity in the world of material objects, nor an entity in the world of meaningful objects, but an event (or situated object) that connects both worlds. It serves as a mediating structure between the here-and-now and the once-and-there. In particular, it presents the manifold of futures given by the different options to change the construction of the artifact now.

We can elaborate the different options further, if we take a closer look at the functional character of artifacts, which also plays an essential role in the evolution of car tires being employed as a means to go sledding. The functional character is not a monadic attribute of a physical object, but a relative feature of physical object and intention. This means it is formally a dyadic relation of a *means* to an *end*. However, this relation is not fixed, but contingent, as its evolution is mediated by a third – the situated object. The further development of the artifact can be realized by changing the relation of *means* to an *end* in three dimensions:

- an evolution of the means which are given by a contingent material construction,
- an evolution of ends which are given by a contingent meaningful construction and
- an evolution of using the means to an end, which are given by the contingent connection between both.

The functional character of artifacts also provides a common ground for two different definitions, namely a production-oriented and a consumption-oriented one. The difference between both is that the production-oriented characterization emphasizes the aspect that artifacts are man-*made* means for an end; the consumption-oriented characterization emphasizes the aspect that artifacts are *used* by man as a means for an end.

1.4.2 Mediating among fragmented experience

One of Marx's major contributions to theoretical thought was his generalization of the Romantic concept of expression as relating to any kind of labor, which allowed him to create a new analytical approach for the study of novel forms of economic production and consumption in society. Having expressive anthropology in mind, labor is not merely a productive achievement, but a formative event as well. Taking this emphatic understanding of labor

seriously, one becomes aware that two different types of fragmentation exist within distributed labor:

- in its productive character, distributed labor is confronted with the need *to coordinate distributed realization (mediation of fragmented work)*
- in its formative character, distributed labor is confronted with the need *to integrate distributed appropriation (mediation of fragmented experience)*.

Inside the core disciplines of IT research, the topic of fragmentation in distributed labor is mainly explored from the first angle, while the second is largely neglected. This might be one reason why only few approaches exists that study the mediating of appropriation (which is mainly done in consumption) and realization work (which is mainly done in production) within distributed commodification. Implicitly, the concept of Participatory Design addresses this issue by arguing for mutual learning, and the use of shared artifacts such as mock-ups as common sources for integrative experiences. With respect to distributed appropriation, Pipek's considerations on appropriation work present to my best knowledge the most sophisticated reflection on this topic up to date.

Outside the core disciplines of IT research, the most notable streams studying the second point are the theoretical reflections on appropriation of commodities in Cultural Theory (cf. Hepp, 2004, chap. 5, du Gay et al., 1997) and the analysis of culture industry as carried out in Critical Theory (Horkheimer and Adorno, 1997, Adorno, 1998).

In particular, Adorno's work harmonizes well with my theoretical approach, as he retains the essentials of the Romantic idea of expression as a self-creative praxis (see Section 1.3), but transforms them to analyze actual forms of consumption in society. Adorno further develops the Romantic idea in his synthesis of aesthetic and social theory, showing the aesthetical dimension of appropriation and specific forms of fragmentation in the ongoing cycle of *commodification*. In particular, his synthesis demonstrates that experiencability and generalizability are not two different phenomena, but to two different qualities in appropriation that can and should be thought together.

In his political economy, Marx uses this Romantic idea to elaborate the objectification of labor as a normative and analytical tool for studying the effects of capitalist dominated production conditions on the wage laborer, concluding that she is alienated from the product she is producing. Adorno takes up these considerations, but uses the idea of expression as an analytical tool to explore the effects of commodification on the consumption patterns of cultural goods. Especially in his writings on the culture industry, Adorno quite explicitly concerns himself with the structural dilemma of innovation development for the specific case of

cultural goods, and the strategies by which culture and media industry chose to handle the dilemma (cf. Horkheimer and Adorno, 1997). These strategies tend to reduce the economical risk of creating innovation (in the empathic notion of emancipatory goods) by producing pseudo- innovations, which can temporarily produce an empty appearance of novelty at high cost to the producer. However, this leads to a new form of alienation which is mainly neglected in literature: The wage laborer is alienated, because *she is robbed of her productive achievement*, but also the consumer is alienated, because *she is robbed of her formative events*.

In his reflection about alienation in consumption, Adorno combine a philosophical and a sociological topic. This synthesis makes Adorno quite complicate to understand, but for the same reason he became a highly relevant theorist to uncover the nature of new forms of participative product findings beyond classical requirement engineering.

The philosophical topic refers to the question of the development of concepts (respectively plans, ideas, knowledge, etc.). The philosophical puzzle is that concepts must bring the manifold of impression to unity (Kant). However, if any impression is subsumed under existing concepts than the question arises where new ideas come from. We can characterize this philosophical problem as the epistemological dimension of innovation development.

In the reception of Kant this puzzle become part of philosophical aesthetic as well as a philosophical logic. For example Peirce approaches this problem from a semiotic-logical side, working out the concept of *abduction* as a third form of reasoning. While Adorno approaches this problem of an aesthetic side, working out the concept of the non-identical in aesthetic experiences. By and large both authors are studying innovation development from an epistemological point of view, however the one focus on the means, while the other focus on the sources. Nevertheless both emphasize the performative element in making aesthetical and surprising experience as a condition for innovation development (which cannot be standardized or replaced by formal specification).

In professional design the performative element become well accepted and sometimes it also used as a distinctive feature to explain the difference between design and engineering. Also current trends of design research such as approaches like *ambiguous design* that stays *open to interpretation* (Sengers and Gaver, 2006, Gaver et al., 2002) or *critical design* (Dunne and Raby, 2001) that takes the aesthetic dimension in account to enable new forms of product finding.

The merit of Adorno synthesis of this philosophical topic with a sociological view on alienation in society is to show that the aesthetical dimension of innovation is not just relevant in

the sphere of production, but also in the sphere of consumption. In particular, his considerations demonstrate that a EUD research is to narrow, if it just focus on tailorability, but neglects the fact that artifacts being a source of experiences that support the self-creation of man.

In literature, Adorno's diagnosis of the culture industry has been widely criticized, especially in Cultural Studies (cf. Kellner, 1997). Adorno - so the critique - draws a quite mechanical picture of passive consumerism and offers a potentially elitist account of culture. In opposite to this, Cultural Studies have mainly emphasized the active role of consumers in the creative appropriation of commodities in their local context (cf. Hepp, 2004). The accusation of elitism leveled against Critical Theory is related to a methodological problem, which is equally relevant for appropriation research in IS. As mentioned above, a positivistic methodology that subsumed the research object under pre-defined operational criteria cannot capture the emerging qualities which appear in appropriation. However, focusing merely on appropriation practices leads to the danger of losing any normative potential with which to judge matters concerning appropriation, and in reaction to this, the more general diagnostic potential previously inherent to the process now vanishes.[16] In order to escape this dilemma, Adorno searches for a place that neither falls into the pitfalls of positivistic nor of affirmative research, however this leads (maybe necessarily) to a position which to today's sensibilities smacks of elitism. Adorno neither argues from a subjective position, speaking as an alienated consumer himself, nor from a positivistic position, presenting operational criteria for measuring the alienation in the commodification of products. Instead, his diagnosis stands with one foot in a structural argument about production conditions, and with the other foot in an aesthetic argument about the produced artifacts of the media industry.

This productive parallelization of social and aesthetic theory is further investigated by Oevermann. Grounded in Adorno's conceptual synthesis, Oevermann has outlined from a sociological point of view an aesthetic theory (inter alia Oevermann, 1996). In particular, he

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[16] See also Poole and De Sanctis (2003) reply to Jones and Orlikowski's critique of AST (see Section 1.1). They refuse the position that "deterministic thinking has no place inside structuration models" (p.206) in using a normative (and not an analytical) argument. They argue that this would lead to unacceptable consequences for IS: "IS scholarship is interested not only in describing the unfolding of human-technology interaction, but also in anticipating the consequences of technology adoption and its use, and in providing systems development advice where possible" (p. 221). I would not follow the argumentation of Poole and De Sanctis, as it seems to me that they confuse non-determinism with arbitrariness and neglect the need to understand a situation, not merely predict its occurrence. However, it shows that methodological reflection on appropriation research carried out in the humanities is also relevant for the positivistic disputes in IS.

carries out diverse analyses of objects of art as a sharpening stone for his methodological approach – the Objective Hermeneutic – which is normally applied to qualitative social research (see above). These sketches have been elaborated in a systematic way by Pilz (2007), explicating from the constitutive structure of aesthetic objects the consequences a methodology has to draw in order to analyze aesthetical objects without denying the openness of life practices. In particular, Pilz has demonstrated that the constitutive structure of *aesthetic objects* is homologue to the structure of *emergent events* in the notion of Mead. This homology between aesthetic objects and emerging event is also the structural argument the reason why Oevermann developed his Objective Hermeneutic in close cooperation with his sociological research on aesthetics (e.g. Oevermann, 1996) and emergence (e.g.Oevermann, 1991). The same argument also holds to demonstrate the homology between aesthetic objects and the situated objects mediating innovation which appears in appropriation.[17]

This homology presents also the underlying link between Adorno's further development of the Romantic idea of expression, and my research endeavor to explore the mediation instances in articulating situated development in distributed evolution.

Adorno's insistence on the aesthetic dimension in consumption suggests that exploration of the artifact present-at-hand in its aesthetic quality is a source of emergent events in the human formation process. His concept of alienation also creates an awareness of how to explore the topic of situated development from the point of view of fragmented experiences in division of labor.

A situated development can be specified as a cut in the here-and-now that is influenced by a manifold of development traces, and influences a manifold of development traces. In this view, the notion of fragmented experience characterizes the disappointment when it comes to making sense of the manifold. This dimension of fragmented experiences in situated development relates to a topic that both Dewey and Benjamin discuss, concerning the fragmentation of experience:

"[Benjamin distinguishes] two different kinds of experience: 'auratic' Erfahrung or integrative narrative experience; and 'technological' Erlebnis or atomized, discrete, fragmented experience." (Kearney, 1994, p. 164)

In a similar manner Dewey criticize the mess of fragmented experience:

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[17] This is also the reason why my research approach (see Section 1.2) makes use of the Objective Hermeneutic as an adequate methodology for appropriation research, where users are latently confronted with emergent objects that appeared in wicked situations.

"[Dewey states that] fragmented experience is the shattering of experience into discrete and arbitrary units that are somehow dissociated from all that made experience in the first place. It is experience that is less than it could be, because fragmented experiences cannot be extended or transformed" (Britzman, 1991, p. 34).

Theoretically, this critique is based on a counter-factual assumption that behind the discrete, fragmented experience an integrative, meaningful object does exist. The existence of such objects presents a hypothetical construct that is necessary in order to speak of fragmentation. Typically, such an existence can be ascertained only in a negative manner. Respectively, only in reaction to an integrative experience can one ascertain in reflection that the situation before this one was fragmented. The integrative experience (which exists only in contrast to a previous, fragmented situation) is therefore closely related to the experiencability of the emerging object which appears in the specific constellation of a situation. The fragmented experience is therefore a derivative concept which rests on the existence of integrative experiences, which itself rests on the possibility of making new experiences. Further, fragmentation can be explored from the subjective as well as the objective side, but one should have in mind that subject and object side evolve in cooperation.

From the subject side, fragmented experience refers to a deficit of a person to be open for new experiences. This side of fragmented experience has been studied by Adorno (1995, first ed. 1959) in his essay on 'half-education' (*Halbbildung*). Essentially, the ideal-type 'half-education' characterizes that man subsumes his own experience under a foreign category. In doing so, man is incapacitated away from the emerging objects that appear in (wicked) situation, because he subsumes the emergent under the existing.[18]

From the object side, fragmented experience refers to the deficit of the (designed) world to be the source for any new experience. This side of fragmented experience has been explored by Adorno in his writings on the Culture Industry, where man produces commodities that do not provide formative events, but present an ongoing reproduction of the same (cf. Horkheimer and Adorno, 1997, first German edition 1947).

This kind of fragmented experience refers to the aesthetical dimension of appropriation. Here, the term 'aesthetical' is not used as in the common notion of beauty, but in the sense of Dewey's (1958) or Adorno's (1998) aesthetic theory. It studies art not just from the per-

[18] The theory of 'half-education' can also used to characterize the two ideal-types of design research methodology. The one can be labelled as 'theory driven design', which subsumes the context under given theories. The alternative one can be labeled as 'situation driven design', which argues that design should rest on a practical rationality.

spective of beauty, but as a source for formative events in the musement (Peirce) of a playful inquiry. It refers to the capacity of aesthetic objects to mediate between meaningful and material reality in the production of a presence (see also Pilz, 2007, Seel, 2005, Gumbrecht, 2003).

The aesthetic critique of fragmented experience is therefore mainly located at the level of the experiencability of situated innovation. This critique is a reminder for emancipatory design that we ought to create *constellations for integrative experience that can be extended*. This means to create artifacts that can be the sources of diverse formative events, artifacts that can provide the aesthetic material for making new and integrative experiences. However, the analysis of the constitution of aesthetic objects demonstrates that there will be no general rules of how such artifacts can be engineered, although the presence and absence of aesthetical quality can be analyzed and discussed by reconstruction-logical design critiques.

A second issue is primarily located on the level of the communicability of situated innovation. It addresses the social dimension of fragmented experience which resulted in the distributed production and consumption, where diverse threads of evolution have to coordinate and articulate themselves on the basis of independent, but interdependent life worlds. Here, the story of the distributed evolution of Excel presented in Section 1.1 gives an example for the fragmentation of experience on the social level. In this case, the integrative experience appears only once the new version interfered with the local development, yet created a knowledge that was needed in the past. So the understanding and communication of the situation have come too late, only in reaction to a technical breakdown. This raises the question of how integrative experience can be provided in a less painful or destructive manner.

This example shows that in distributed realization and appropriation work, the dissociation of experience attains a new, social quality. In this case, fragmentation did not just affect the individual subject, but the social subject as a whole, which is constituted by the *circuit of commodification* (du Gay et al., 1997). On the social level, the fragmentation arises from the fact that the social subject is shattered into discrete and distributed agents.

This fragmentation of the distributed agents also affects the articulation of situated innovations. In general, the articulation has to solve the philosophical puzzle of communicability in praxis, expressing the unknown but using known concepts without erasing the newly appearing innovation. In such situations of establishing new concepts, the aesthetic quality of experience plays an essential, role as it provides the bedrock for the meaning of the newly

arising concept.[19] In other words, communicability is bounded by experience. In the case of the social subject, the fragmentation of experience means that the diverse experience horizons of agents are dissociated and shattered into discrete and arbitrary units which cannot communicate with another and thus cannot form a functioning unit even temporarily. Regarding the distributed software evolution, this is related to the fact that articulating situated innovations on the public stage must (re-)construct the emerging object before the backdrop of the agents' dissociated and heterogeneous experience horizons.

The challenge to mediate situated innovations between dissociated agents has been studied in more detail in Stevens et al. (2009b). In the empirical study presented in Stevens et al. (2009b) we take a closer look at the articulation of situated innovation between the worlds of users and designers. In this empirical study, it became obvious that mediation cannot be reduced to transferring objects from one life world to the other, as there is also a need to translate the object into a different language for this to be possible. Moreover, mediation is also faced with the problem that a situated innovation attains meaning in the other world only if existing interpretation schemes and experience horizons are transformed in the sense of a creative destruction of what is, forming new communicative links that enable communication between different worlds by means of slow and often painfully established organic patterns of growth.

The social level of fragmented experience generalizes the problem of the symmetry of ignorance between designers and users (Fischer, 1999) and the problem of sticky information located in the use context (von Hippel, 1994). The analysis of the underlying structure of the problem demonstrates that the fragmentation of experience cannot be solved mechanically, also since the provision of appropriate sources for integrative experience must be accompanied by openness for making new experiences. Nevertheless, the articulation of situated innovation should be supported by tools which allow the sharing and translating of dissociated experience horizons. This I explore as the role of the artifact present-at-hand in the articulation of situated innovations.

1.4.3 Artifacts as mediation structure

In the previous sections, I mainly focused on the dialectical constitution of artifacts, and the topic of fragmentation in distributed evolution. In this section, I will explore the role of the

[19] This is related to Pragmatism-based meaning theories which argue that knowledge is made up of our embodied experience and our social practices (e.g. Brandom, 1994).

artifact serving as a mediation structure in this distributed evolution. Therefore, I will elaborate the thoughts of Section 1.3 about boundary objects as a specific kind of meditation structure.

The concept of boundary objects is not only interesting for theoretical reasons (see Section 1.2), but it is also a promising candidate for bridging analytical and constructional research. In literature it is a well-known analytical tool for the study of distributed cooperation and knowledge construction (e.g. Carlile, 2002, Engeström and Miettinen, 1999, Star and Griesemer, 1989) as well as being in use as a conceptual framework to guide distributed software development (e.g. Bertelsen, 2000).

With respect to my constructional intentions, the most relevant work on boundary objects has been carried out by Fischer in his considerations on design externalizations serving as boundary objects (Fischer, 2001). In this work he highlights that:

> "[design externalizations as b]oundary objects […] can serve two major purposes (1) they [the boundary object] can serve as objects to support the interaction and collaboration between different communities of practice, and (2) they can serve the interaction between users and (computational) environments. In this later case, one can argue that they serve the interaction between the users and the designers (being present "virtually" through the system created by them)" (Arias and Fischer, 2000, p. 569, Fischer, 2001, p. 73).

I adopt Fischer's considerations about externalizations of design issues (ideas, concepts, and goals as well as resultant artifact) and the different purposes they have as boundary objects.

His remark can be interpreted in two different ways. Firstly, the boundary object given by design externalizations can be used for different purposes. Secondly, the design externalizations embody different forms of boundary objects that serve different purposes. In my thesis I follow the second interpretation, asking for the different forms that are embodied in the artifact present-at-hand.

To ascertain the different forms systematically, I started with a formal analysis of the boundary object as a specific mediation structure (see also Section 1.3). To carry out this analytical endeavor, I abstract from the subject matter and interpret the formal structure from a Peircean view.[20]

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[20] In Section 1.3, I noticed that the dialectic logic of Hegel seems also to present suitable tools for studying mediation structures. However, also as I am socialized in modern mathematical logic (cf. Koepke and Burghardt, 1996) and not in philosophical logic, I have a closer affinity to the work of Peirce. Therefore, I adopt Peirce's pragmatist logic and his category systems (Baltzer, 1994, Müller, 1999 give a good introduction in the topic).

In the Peircean universe, a mediation structure is represented by Thirdness. For Peirce, Thirdness is a universal category of being, and the exemplary case of Thirdness are signs in their function to "stands to somebody for something in some respect or capacity" (Peirce et al., 1987, § 2.228). Formally, Thirdness is a hierarchically ordered triadic relation; ontologically it is the "mode of being of that which is such as it is, in bringing a second and third into relation to each other" (Peirce et al., 1987, § 8.328). Peirce introduces Thirdness as a necessary condition for the possibility of experience. In the same manner I argue that Thirdness is also a necessary condition for representing the dialectic artifact in its co-evolutionary nature.

Moreover, Thirdness enables the mediation between the here-and-now and the once-and-there of objects so as to preserve the continuity of identity in the evolution of an object. Within this angle of observation, the constitutive structures of boundary objects mediating social space and social time are in some ways homologue to one another, as in both cases, Thirdness is engaged with, constituting a shared mode along which the lived parallels can be re-engaged with in theory.

Studying boundary objects at such a level of generality makes it possible to further elaborate a remark of Star (1990, p. 43) that the mediation function of boundary objects between social worlds is structurally the same as mediating the continuity of identity in the evolution of open systems. I present a brief example of spatio-temporal mediation, before I give an argument for the necessity of the continuity of identity for the socializing of evolutionary objects.

In the temporal dimension, boundary objects mediate between the now and the once of an object. The mediation of social time can be illustrated by a wedding situation, where the directive speech act "Will you take this man to be your lawful wedded husband?" mediate between the now of 'this man' and the once it will be a '*lawful wedded husband*'. The *once* of the actual situation is further structured by the subsequent declarative speech act, where the options "yes" and "no" represent two different futures. The *once* therefore refers to a social orderliness of time, structured by the social modalities of action.

In the spatial dimension, the boundary object mediates between the object from the perspectives of here and there. The mediation in social space can also be illustrated by the wedding situation that mediates between '*this lawful wedded husband*' from the *perspective of the self* who is asked, and from the *perspective of the others*. The 'husband' has a different meaning for the person who is going to marry this man and for the person who has an affair with this man. The meaning therefore also depends on the subject perspective the

object is viewed from. Each *here* is the center of a subject, which as the subjective centre of a situation constitutes a perspective which can - using this focus of self – create the meaning of objects of its surrounding reality, and by means of reflecting on this perspective can continually further the own self-knowledge. In relation, *there* refers to places where the object is given by another perspective. The meaningful object therefore only exists in the reality of diverse perspectives, and not as a thing-in-itself.

The *here* therefore constitutes a perspective where objects receive a meaning, while *there* refers to places where the object is given by another perspective. *Here* and *there* refer to the diversity of perspectives which generate a social order of space. The mediation structure is needed to put these diverse perspectives into relation so that objects attain a social identity.

This general remark also holds for the case of evolutionary social artifacts, and the continuity of identity across different realities in social time and space. From a structural point of view, evolution is only possible if there is a continuity of identity, otherwise there will be no evolution of an object, but a manifold of unrelated objects co-existing in different social times. The same argument also holds for objects in the collaboration between different communities of practice. Without a continuity of identity, there will be only a manifold of unrelated objects in social space.

We can further explore this thought from a retrospective perspective on innovation development, which can be characterized as a passage in development from a previous state to a new one. Following a mean value argument to study the mediation processes' continuous development of the artifact, we can postulate with Mead that in the "passage the emergent lies in both, and is what it is because it carries the characters of both at once" (Mead, 2002, p. 98). Hence, the special feature of artifacts present-at-hand in the passage of their continuous development is to serve as a boundary object which mediates between different perspectives.

This form of a mean value argument presents a variation of the argumentative strategy of Star, who implicitly also relies on a continuity argument. The formal argument by Star can be expressed as follows: If social world A and social world B cooperate, there must be something that neither can be reduced to being either A or B, but that belongs to A and B at the same time. This mean value argument of sociality of different social worlds is homologue to the mean value argument of emergency of different states of a social world: If social world A' is a transformation of social world A, there must be something that neither can be reduced to A or A', but belongs to A and A' at the same time.

As indicated in the quote from Mead (2002, p. 87) and elaborated by Oevermann (cf. Wagner, 2001), a theory concerning the socialization of subjects needs both, mediation of social space as well as of social time. Because of the fact that appropriation is the socialization of objects, I was forced to enhance Star's concept of boundary objects by the dimension of mediation between the existing and the emerging. This does not mean that the concept of appropriation as a 'socialization' theory of objects must level the difference between object and subject. Instead, the suggested concept of appropriation relies on an asymmetrical relation between subjects and objects.[21]

In summary, the continuity of identity is constitutive for the existence of objects that have different meanings in time and space. In other words, the existence of mediating structures presents a necessary condition for the existence of objects which have the capacity of being several things at once. In particular, the possibility of expressiveness and hence the dialectic artifact itself is only possible through the existence of mediating structures. The dialectical artifact embodies a mediating structure which preserves a continuity of identity in social time or space.

This structural view on the socialization of evolutionary objects also enables a better display of the underlying connections between the diverse non-reductionistic positions I refer to in my theoretical foundations (see Section 1.3). These can be interpreted as different research positions which implicitly or explicitly rely on structural features which are given by the existence of mediation structures. Inversely, they can be used to characterize mediation structures through their diverse occurrences. Mediation structures are therefore characterized by the following structurally equivalent features:

- to be a situated innovation that presents as a productive achievement, but as a formative event as well (adoption of the characterization of Expressivism in Section 1.3),
- to be both plastic enough to adapt to different social worlds, yet robust enough to maintain a common identity (adoption of Star's definition of boundary objects),
- to carry more than one perspective at once (adoption of Mead's definition of sociality),

[21] In the underlying theoretical architecture, this presents a fundamental difference to other concepts, which rely on symmetrical relations (as this seems to be the case in the Actor-Network-Theory, cf. Randall et al., 2007, pp. 104).

- to be a duality that is outcome of and medium for agency (adoptions of Giddens' definition of structuration), and
- to be a sign that mediates between *the manifold of the present* and *the generality of concepts* (adoption one of Peirce characterizations of Thirdness).

The structural view links the sociology of knowledge (Star) with the evolutionary view on structuration (Giddens). One advantage of drawing such connections is the possible transfer of argumentation. For example, the core structuration argument posited by the duality of technology is the recursive mediation of agency and structure. Adapting this argument, we can state that boundary objects are given by a recursive mediation of social practices. This means that boundary objects posit a duality, being both medium and outcome of social practices.

The homology between evolutionary and social object is first of all a statement about form, and not about content. However, figuring out general constitutive structures provides the required analytic tools to explore systematically the artifact in its function as a boundary object in the public articulation of situated innovation (see Section 1.3). In Section 1.4.1, I have further outlined that emergence starts with contradiction, which constitutes a wicked situation where the artifact becomes present-at-hand. This thought can now be further elaborated. The constitutive centre of the wicked situation is the here-and-now that is connected with the once-and-there by the artifact present-at-hand. This means that the artifact present-at-hand mediates and in doing so, co-constructs the spatio-temporal identity of the object. In this sense it serves as a situated, evolutionary boundary object. From this perspective, I explore the role of the artifact serving as a mediation structure corresponding to the different stages in the evolution of public articulation of situated innovation as outlined in Section1.3. The resulting analytic model is illustrated in Figure 3.

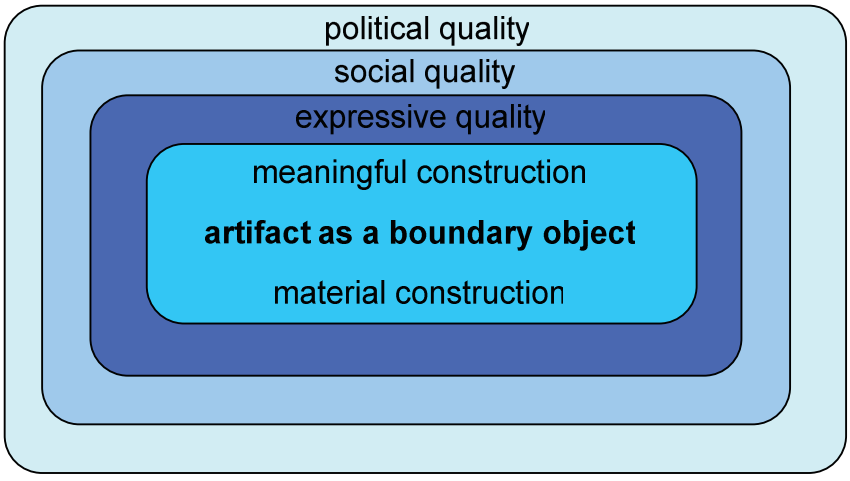

Figure 3 Schematic view of the different qualities of the artifact serving as boundary object

The model of situated, evolutionary boundary objects is grounded in a dialectic constitution of artifacts as being materially and meaningfully constructed objects. The different stages of the boundary object follow the different mediation instances which occur in the public articulation of a wicked situation. In the evolution of a wicked situation becoming of general interest, we can identify three different forms of mediation:

- The *first form* is constituted by the identification of the wicked situation as an emergent present. This form is linked to the *experiencability* of a life practice given by the possibility of reflection, when human actors have a chance to step out of the nexus of action. It mediates between an unidentified reality which has irrefutably attracted our attention, and the possibility of identification as expressed by the utterance of *"There is something"*. From the evolutionary anthropology outlined in Chapter 3, this moment would be constitutive of the possibility of being alienated from nature, as well as the possibility of appropriating nature. The form of mediation structure is given by the concept of expression that sublates the concept of man and nature. I define the artifact present-at-hand in its embodiment the first form of the *expressive boundary object*.
- The *second form* is constituted by the identification of the wicked situation as a contradicted past. This form is linked to the *communicability* of life practice given by the possibility of identifying emerging objects as 'nonidentical' (Adorno, 1983) *("This is not a sled")*. The nonidentical object sublates the here-and-now and the once-and-there in constituting an appearance that allows reflection on the situation from the perspective of the 'generalized other'. More precisely, the 'nonidentical' and the 'generalized other' (Mead, 1983) are mutually constitutive of sociality as the capacity of being several things at once. The former provides the transcendental object outside the here-and-now, which is a necessary condition for the possibility to translate between the multiple perspectives. The latter provides the transcendental subject outside the here-and-now, which is a necessary condition for the possibility to generalize the diverse perspectives. They are transcendental because they exist in a once-and-there that transcends the here-and-now of the present situation. In this form, the artifact present-at-hand mediates the once-and-there of the diverse meaning constructions. The second form is a qualitative transition of the first form, as the mediation of diverse meanings operates on the mediation of an expressive nature in the here-and-now, but transcends it. I call the artifact present-at-hand in its embodiment of the second form the *social boundary object*.

- The *third form* is constituted by the identification of the wicked situation as anticipated future. This form is linked to the *generalizability* of life practices, given by the possibility of identifying emerging objects as potential desired ones *("This should be a sled")*. The anticipated future hypostasizes the appearance of the once-and-there, and in doing so it constitutes a sphere of making decisions which cannot be reduced to sense making. I call this new quality the political sphere. In this political sphere, different perspectives are mediated by taking the role of the generalized other (which was constituted in the previous stage). Taking the role of the generalized other is needed to appropriate a wicked situation in its general interest, which requires taking into account the anticipated futures contained by the diversity of perspectives. In doing so, the rationality of the possible futures regarding the social artifact present-at-hand is mediated by the general interest. The existence of a general interest makes it possible to put one's own and others' interests into relation, and to thus negotiate the realization of future plans. The third form is a qualitative transition of the second form, as the mediation of diverse interests also operates on the mediation of diverse meanings. I call the artifact present-at-hand in its embodiment of the third form the *political boundary object*.

This gives a brief outline of the different mediation instances in the public articulation of situated innovations that are embodied in the artifact present-at-hand. The resulting model of a situated, evolutionary boundary model takes place within the constitutive relations between different mediation forms: The articulation of a design issue that is of general interest marks a temporal end of the genesis of a wicked situation. In this sense the *political boundary object* presents the highest level in the evolution of mediation structures, where the design issue is judged from the perspective of the generalized other. However, a constitutive condition of any role taking is the existence of the role in the first place. This role is constituted by the mediation of the diverse perspectives which refer to the same object (given by the *social boundary object)*. Further, the constitutive condition for the diverse perspectives to exist is given by the possibility to step outside the flow of action for better or worse, so as to perceive the situation as an emergent one (which is given by the *expressive boundary object*).

One reason for this explication of the various stages in the evolution of a wicked situation is to increase awareness of these diverse capacities, all of which are needed to articulate a situated innovation, and all of which are of general interest.

The resulting model of the boundary object as embodied by the artifact present-at-hand differs from Fischer's considerations in two points. The first point refers to the relation between different forms of a boundary object. It seems that Fischer explores the interaction with the artifact from the perspective of it being an interaction with the designer, mediated by the artifact. Instead, I explore the interaction with the designer from the perspective of the user's interaction with the artifact. These different perspectives are closely related to the difference between a production-oriented and a consumption-oriented view on the constitution of artifacts.

This also relates to the decision that needs to be taken about whether the analytic model should uncover an internal or an external perspective of the social actions which are mediated by an artifact. From the external perspective, the analytical model should enable one to reconstruct the instances of mediation which have occurred in the social activities of an examined case (like in the case of Star and Griesemer, 1989). From the internal perspective, the analytical model should explicate the mediation instances that are latently available in the flow of action confront an open future.

Internal and external perspective thus provide complementary views of the same topic. However, whether one interprets the situated action from an internal or an external perspective lends rather different meanings to Fischer's description that in the interaction designers are *being present virtually*.

From an external perspective, the phrase refers to the fact that the system itself is one necessary condition of the examined situated actions. The system as a designed condition of action creates a factual connection between the social practices of the user and those of the designer. This is possible because the artifact is a boundary object which is plastic enough so that both practices can co-exist within its use. In this sense, the designer is "virtually" present. However, such a view runs into trouble when we use natural objects (a stone) as an artifact (a hammer). Suddenly, it is not at all clear who is the virtually present designer!

From the internal perspective, the same definition can be interpreted as meaning that the role of the designer becomes visible in a wicked situation, as one reflects about the artifact present-at-hand. From this point of view, the situation where the artifact present-at-hand becomes part of the construction of meaning of the object; it also becomes a part of the construction of the related social practices and their corresponding roles. In this sense, the

designer becomes “virtually” present in a situation of human interaction (rising to view in the wicked situation like an oasis to desert travelers in need of water).[22]

The second difference to Fischer’s considerations is that my resulting model presents a more fine-grained description of the various purposes of design externalization. Here, the different forms refer to different purposes, so that we attain at least three purposes of design externalizations in reflective technology development (see Section 1.2):

- A purpose given by the expressive quality is the realization of ideas, but also a source for the formation of ideas (indicated by Fischer, but not explicated in its own logic),
- a purpose given by the social quality is the translation of the diverse meaning constructions of the participating agents (as mentioned by Fischer and Star), and
- a purpose given by the political quality is the clarification and negotiation of the diverse interests of the participating agents regarding a desired future (indicated, but not explicated by Fischer and Star).

The analytical model of a situated boundary object also allows further clarification of what *reconstruction-logical appropriation research* means in studying situated development. Methodologically, one has to study the evolution of a wicked situation in its inner structuration in order to explore systematically the usages and social constellations which are mediated by the artifact present-at-hand (e.g. in the collaborative reflection between colleagues), and the way users structure the situation so as to make the emerging object accountable. This is what happens in a wicked situation. The complexity of this task is also related to the different stages of expressing a new experience which are of general interest for an unknown public community (see Chapter 4).

Last but not least, such a constructivist view on wicked situations also allows the study of appropriation phenomena where the use of artifacts goes beyond the intention of the designer. Omitting these cases means both, to omit a large amount of phenomena, and to ignore precisely the forms of misuse which broaden the object’s potential uses.

[22] The appearance of an oasis in wicked situations can lead to an inquiry process where in the evolution of a situation, the object is identified as a fata morgana. However, even in the case where the oasis is an illusionary sign, it posits a reality in the world of situated objects that leaves ontic and epistemic traces.

1.4.4 Supporting situated development

The previous sections have demonstrated that appropriation is a constitutive element in the structuration of technology (cf. Orlikowski, 2000, Orlikowski, 1992). Following the duality of technology, information systems are not only a medium of social practices, but also the outcome of social practices. In this process of structuration, technology evolves in its socio-material construction. Further, the structuration of technology is embedded in a continuity of action. The wicked situations' cut into the continuous structuration of technology constitutes the here-and-now of a *situated development*, which presents as event and flow at once.

The situated development is further given by the presence of an inner and an outer perspective. From the outer perspective, the situated development is relatively determined by the existing evolutionary socio-material structure; from the inner perspective of agency, the situated development is an open future, given by the appropriation of the socio-material structure which is itself given by the development situation. In this situation, the artifact present-at-hand appears as a boundary object mediating a distributed and fragmented *web of development traces* which constitutes the evolving structure. The exploration of mediation instances in the articulation of a situated innovation has further revealed which capacities are needed to appropriate such a wicked development situation.

In particular, the relations between d*evelopment trace* and *a situated development* are mutually given. A development trace is relevant for a situated development, if it should be taken into account from a retrospective (and therefore only counter-factually given) perspective of an integrative experience. Vice versa, a situated development is relevant for a development trace if it is or might be affected by the development event which is produced in the situation. The mediation of the boundary objects therefore has two functions. First, from an external view, the mediation structure should enable the collaboration and articulation of mutually relevant development traces, providing the means for translation and co-existence among these traces. Second, from an internal perspective, the mediation structure should enable the appropriation of fragmented traces in a situated development, thus providing the means for integrative experiences.

In particular, with the help of the boundary object model elaborated above, we can define the situated development more precisely:

i) A situated development is specified as a cut in the here-and-now of the relevant development traces. Further, it is a developmental event in the flow of the socio-material structure.

ii) The center of the cut is given by the agency of an individual or social subject. This constitutes a perspective on the wicked situation of development.

iii) The social-material structures of the developmental traces are not directly given, but mediated by the artifact present-at-hand which serves as a boundary object.

iv) The relevance of traces depends on the open future of a situated development; however, heuristically it can be explored by generalizing from the manifold pasts and anticipated futures of the existing traces.

An illustration of this view on socio-material structuration as mediated by boundary objects is given in Figure 4.

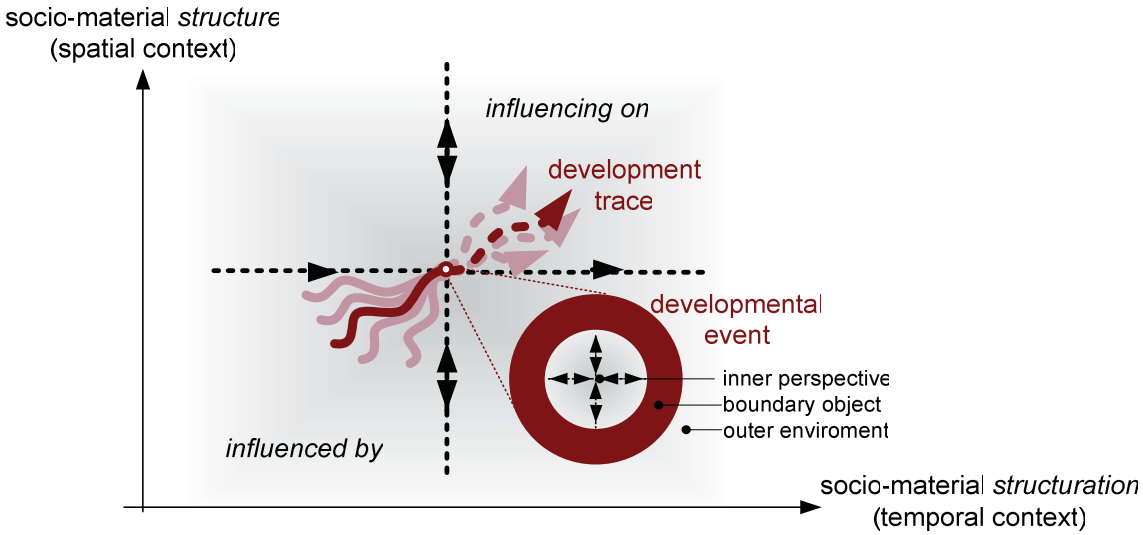

Figure 4 The structuration of technology as web of traces that evolves in the flow of developmental events

A specific feature of situated development is that on the one hand, it is an event in the flow of the affected development traces. On the other hand, it is a critique of the flow in reconstructing the situation from an internal and an external perspective.

This temporal dialectic is also outcome of the fact that a situated development is latently a moment of situated innovations which

> "require thinking imaginable possibilities [which have as yet] neither been known, nor can be justified on the ground of empirical experiences, but have to be tested in the open future and confirmed practically" (Oevermann, 2005, p. 140).

However, this does not mean that innovations are created ex nihilo, but that the possibilities are grounded in the potentiality provided by actual constellations of the manifold of development traces. In this sense, event and traces cannot be reduced to each other's terms, and yet act as mutually constitutive elements of situated innovations. Moreover, the traces of an emergent event are given by a "combination of relative determinism and future reconstructionism" (Farrell, 1947, p. 180).

The primary goal of the Appropriation Infrastructure as stated in Section 1.2 is to support users to express and discuss situated innovations. Having the required theoretical material at hand, this goal can be further elaborated as: *the Appropriation infrastructure should sup-*

port the appropriation of development situations so as to enable the change of the development traces in an intentional way by using the existing socio-material structure constructively.

The goal is therefore to support the mediation between the here-and-now of the development situation, and the once-and-there of the web of development traces. This view on situated development also allows the re-interpretation of existing work in EUD, and its integration in a conceptual design framework. For example, the creation of tailored artifacts (Kahler, 2001) can be reinterpreted as the creation of a development with special focus on changing its material construction. However, in taking the *event character* as part of the production of the affected development traces into account, we can integrate the creation of tailored artifacts into Pipek's (2005a, p. 63) conception of the historicity of EUD activities. Defining developmental events as only existing in specific constellations of traces concretizes Pipek's (2005a) work by emphasizing that EUD activities are shaped by history, and present a flow in history which changes artifacts in their socio-material construction. In addition, the appropriations of development situations are also confronted with the challenge to explore anticipated futures from the inner perspective and articulate them *within and for* the affected development traces. This means *that* an Appropriation Infrastructure should not just *support users to explore the* past *of development traces*, but *also support users to simulate and articulate* anticipated futures of the traces.

Pipek (2005b, sec. 4.5.1) also points out that one should differentiate between the inner and outer tailorability of artifacts. If we interpret a particular artifact as a dot on the socio-material surface as illustrated in Figure 4, we can characterize the difference as follows: inner tailorability presents the potential to change the dot in its internal socio-material structure, while outer tailorability presents the potential to change the dot in its relation to the surrounding socio-material structure. In addition, we can use the model to also introduce the notion of inner and outer tailoring activities within the socio-material structure. An inner tailoring activity only affects and takes into account the interior socio-material structure of the dot. In contrast, outer tailoring affects the relation to the exterior socio-material structure.

From an analytical point of view, an internal and an external area must exist in some way; however, the border between the two is often so blurred that it can be unclear whether a situated development presents an inner or an outer tailoring activity. This difficulty of perception is not helped by the fact that it ultimately depends on the further evolution of the affected traces. So, it will be difficult to separate outer and inner tailorability in practice.

However, using the artifact present-at-hand as the centre of a situated development, an Appropriation Infrastructure can support the user in exploring and judging what is or should be the inner and the outer of any tailoring situation. Supplementary to the user-designer perspective, the challenge lies in the design of an environment which offers enough common ground horizontally across a product community, yet is also plastic enough to respect the vertical depth of each agent's autonomy in their personal adaptations.

Situated development can be located at every point in the consumption or production of an artifact, and in some sense each design activity presents a situated development. So, the present model does not present any criteria with which to distinguish professional from end-user development; instead it provides an interpretation scheme for studying development processes as they occur, which is always situated. However, due to my EUD interest, I am primary interested in wicked situations, where the artifact in a use becomes present-at-hand.

In order to support such situated developments in the use context, an Appropriation Infrastructure should be embedded in software artifacts which are used in daily life. These software artifacts should be enhanced by features with which to explore the pasts and futures of the relevant development traces, and are able to be changed in a purposeful manner.

In particular, the Appropriation Infrastructure was guided by the evolutionary model of boundary objects as existing in two dimensions in order to support mediation in the ongoing cycle of software evolution from a user perspective:

- Firstly, the design should support the mediation between the symbolic construction of artifacts (which consists in additional help documents, discussions, user community forums, etc.) and the material construction of artifacts (which is expressed in its component architecture, the tailoring options, etc.).
- Secondly, the design should support personal talk back with the wicked situation, but also allow users to articulate and share their experience if the subject is of communal interest (e.g. discussion with co-workers or friends) as well as transforming it into a discourse topic within socialized practices (e.g. public user community, producers of the core product or available extensions etc.). In addition, an Appropriation Infrastructure should be designed in such a way that a smooth transition between participation in different practices is well supported.

1.5 Outline

The basic structure of my thesis' argumentation is as follows:

Chapter 1 has given a first introduction to my research topic, the mediation of situated innovation in the evolution of distributed software. This topic is discussed from its practical and its theoretical side, and the contribution of my thesis explained. In addition, the chapter provides a short overview of the methodological stance taken, and introduces the major theoretical constructs used to explore the general structure of mediation in the evolution of a distributed software artifact. This understanding shapes the design space in which the Appropriation Infrastructure proposes an original contribution towards solving the previously outlined problems.

Chapter 2 gives a survey of the literature relevant to evolutionary software systems. The survey convinced me that the continuous development of software in its various facets is becoming an increasingly important research topic in IS and innovation research. Chapter 2 demonstrates that the concept of appropriation might be so far the most sophisticated framework with which to study in-situ design as a situated evolution in the context of use.

Chapter 3 gives an overview of the origins of the concept of appropriation. This chapter is important for different reasons. First of all, it elaborates the semantic field of the term appropriation, providing a brief introduction to the role which the concept of appropriation plays in Marx's work. Secondly, Jones (cf. Jones, 1999, Jones and Karsten, 2008) has criticized that the introduction of the concept of appropriation leads to a revitalization of dualistic perceptions of technology development in IS. In Chapter 3, I demonstrate that this argument does not hold if we interpret appropriation in its original spirit as a term which describes an evolutionary anthropology.

Chapter 4 introduces an evolutionary model of artifacts serving as boundary objects. It adapts Fischer's thoughts on artifacts serving as boundary object. Applying the dialectic thinking on sensuality and sociality outlined in Chapter 3, the artifact is interpreted as an evolutionary boundary objects which covers an expressive, a social and a political quality. The function of Chapter 4 is to introduce with the suggested boundary object a bridging concept which can stand between the analytical perspective on appropriation, and the construction-oriented perspective on appropriation support.

Chapter 5 presents the design of Appropriation Infrastructures on a more general level. The artifact which becomes present-at-hand is interpreted as a source for in-situ design activity. This marks a point in the local development of socio-material structures where latent seeds of situated innovation can emerge. Applying the suggested boundary object conception, Chapter 5 elaborates the software-technical architecture of an Appropriation Infrastructures

which interweaves the evolution of the corresponding socio-material structure in general with the local context of a developmental event.

Chapter 6 presents a design study of a first version of an Appropriation Infrastructure implementation in practice. In addition, it presents an evaluation of this implementation based on our first experiences with using the system in an Open Source project, following an Action Research methodology.

Chapter 7 concludes by re-considering the concept of Appropriation Infrastructure in the light of the implementation outcomes, and provides suggestions and perspectives for future work.

I have listed my previous publications in Appendix 1 to document the complex series of steps in practical implementation and support as well as in academic research, communication and debate which ultimately led to the understanding and evaluation of the appropriation of software systems put forward in this thesis.

2 The evolution of the idea of continuous development

In the following I give a survey of the research on evolving software. The survey demonstrates that interpreting software as an evolving object was not self-evident in literature, but considerably contributes to the progress of Software Engineering. The progress generated tailorable products and agile production as two different strategies answering the same demand to support the evolution of software. Last but not least, the survey shows that appropriation research currently provides the most sophisticated analytic lens for studying the situated development of software.

It seems self-evident to recount the history of an idea chronologically. However, history is not always as linear as it looks like at first sight. For example, from a retrospective point of view one can sometimes identify initial forms of an idea that are applied by practitioners, who at the time are not fully aware of the underlying rationality of their own practice. The opposite case is possible as well. An idea has been elaborated in theory, but it is not realized in practice. The issue becomes more complicated if the evolution of ideas is neither isolated from their realization, nor is there direct functional dependency between both levels. Moreover, ideas are often like fashions that come and pass. This makes it difficult to force different stages in the development of an idea into a linear, chronological order.

This general remark on the evolution of ideas is also valid for the case of evolutionary software development. For example, in their historical overview of evolutionary software development Larman and Basili (2003) point out, that in retrospective, one can identify many fathers of an idea in history:

> "Although many view iterative and incremental development as a contemporary practice, its application dates as far back as the mid-1950s" (p. 47).

The brief introduction of the historical perception of the evolutionary character of software artifacts does not intend to present a full reconstruction of the historical contingencies and influences in the development that shaped the formation of the idea. Instead, the goal of this excursion is to outline major interpretation schemes concerning the (continuous) development of software artifacts that shape my own perspective of that topic.

2.1 Software Engineering: From the 'pleasantness' problem to the 'always under construction' principle

In the early days of IT research, programs were seen as computational solutions to mathematical problems. Therefore, the major interpretation schemes in that time treated software

development as solving atemporal mathematical problems. This implicit scheme becomes apparent in the 'firewall'-debate, with Dijkstra and Denning as main opponents. The debate was about the reasons leading to the so-called Software Crisis. Dijkstra (1989) argues that computer science has to concentrate on formal aspects of software development, while Denning et al. (1989) promote an alternative interpretation scheme. For Dijkstra, the essence of the problem lies in the (algorithmic) complexity of computer systems and not in the evolutionary nature of software in practice. In order to concentrate on the core problem, he suggests to establish a disciplinary firewall, which separates the pleasantness- from the correctness problem:

> "The pleasantness problem concerns the question whether a system meeting certain formal functional specifications would satisfy our needs, meet our expectations and fulfill our hopes. The correctness problem concerns the question whether a given design meets such a formal functional specification" (Dijkstra, 1989).

Apart from the fact that the suggested firewall describes a specific form of the division of labor, the pejorative connotation also expresses a 'model-platonistic' view on the development of software artifacts. In order to explore this point in more depth, it is useful to broaden the perspective by studying design concepts in general. By doing so, we can combine Dijkstra's model-platonistic view with the work of Simon (1969). The core idea of Simon's conception in his "Science of the Artificial" is that design can be understood as solving a mathematical problem. The goal of design is to search in a formalized space for the optimal solution given by a utility function.

We can formulate the 'problem solving'-dogma with the help of the functional character of artifacts as means to an end*:* In this view the end is specified by a utility function. The design space is then given by the universe of all means to reach the end while laws of nature specify the constraints of the space. The artifact is then specified as those means given in the design space that maximize the utility function. This view allows applying mathematical methods on practical problems by introducing the idea of a closed and static design space. For pragmatic reasons, the construction of a static environment can be useful, for instance if one wants to tackle a specific subject without getting disturbed by the random noise of the environment. Dijkstra's firewall presents a strategy to create such static space. Unfortunately it comes along with a model-platonistic worldview which presents a false ontologicalization[23] of the pragmatically motivated model-construction.

[23] The false ontologicalization is to argue that the world is a mathematical model, instead to arguing e.g. that the mathematical model will be a tool we use to analyze our design space or our assumption about the world.

The advantage of Simon's (1969) approach is to make the (ontologicalization) explicit. However, the concept of bounded rationality argues from a model-platonistic worldview. For example, Dasgupta (1991) interprets the development of artifacts from a perspective of bounded rationality, which agrees with the position that in practice the optimal solution for a given design space can only be found approximately be found, because of "limits on the cognitive and information processing capabilities of the […] agent" (Dasgupta, 1991)

The advantage of Simon's (1969) approach is to make this ontologicalization explicit. However, the concept of bounded rationality also argues from a model-platonistic worldview. For example, Dasgupta (1991) interprets the development of artifacts from a perspective of bounded rationality, which agrees with the position that in practice the optimal solution for a given design space can only approximately be found, because of "limits on the cognitive and information processing capabilities of the […] agent" (Dasgupta, 1991). Talking about limited capabilities implicitly suggests that a complete and consistent design space exists in principle, but cannot be constructed because of practical limitations. This demonstrates the ontologicalizing tendency of this view. Therefore, on the theoretical level there are fundamental differences between a relaxed static and an evolutionary worldview, although both positions draw similar practical consequences for organizing design processes.

In the literature, Simon (1969) and Dasgupta (1991) are representatives of a (relaxed) model-platonistic worldview, while Schön (1984) and Rittel (1972), respectively Rittel and Webber (1974) are representatives of a school of thinking that emphasizes the moment of practical experience, a situation in which it does not make sense to talk about the bounded rationality of that experience. Generally speaking, the former school of thinking argues from a formalistic-static, while the latter argues from a constructivistic-evolutionary perspective.

In most cases, formalistic-static argumentations do not deduce the desired ends from a universal world model, but take them as externally given. In particular, questions about the evolution of needs are beyond the scope of this theoretical conception. This school of thinking neglects the phenomena of situated development and the evolution in appropriating technology. This is also because Software is viewed as an 'immaterial' entity. Here immateriality not only means that software is constructed out of a digital material. It also means that the essence of software is a platonic idea of an algorithm and not a concrete artifact that people can interact with. Having this in mind, it is not surprising that Dijkstra does not

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To state that is a false ontologicalization express my conviction and I hope, that my argumentation provided in this thesis provide good reasons for that opinion.

reflect on the evolution of practices (along with the evolution of corresponding needs and artifacts).

In the debate with Dijkstra, Denning represents the alternative position. He does not identify the immanent complexity of software systems a as source of the so-called Software Crisis, but determines the understanding of human work in the respective application domain as the core problem for building software applications. According to Denning, the discipline of Software Engineering cannot be built inside the firewalls of Dijkstra's approach, as the perspective has to be broadened in order to take human practices in the application field into account. This does not necessarily imply that we must study these practices from an evolutionary point of view, but the adoption of a revised perspective seems necessary for the development of a true understanding of the evolutionary nature of software artifacts.

Another problem for the acceptance of a radical evolutionary perspective was the widespread notion in Software Engineering that software development should be organized in separated stages which have to be in a strictly linear order. '*Do the requirements, then design and then implement'* was considered best practice (cf. Larman and Basili, 2003).[24] A sound software development project therefore has to start with a complete choice of requirements and an up-front formal specification of the whole software system. Only after completion can the system be rolled out and tested in practice.

With regard to the discussion about design concepts, the waterfall model is like an industrialized version of a model-platonistic design approach: After fixing the informally given ends through their transformation into a formal requirement specification, the software development can concentrate on finding an approximated solution in the formalized design space. The fixation of the moving target of requirements creates a firewall that is useful for practical reasons. However, as a model-platonistic dogma it has the tendency to follow the chimera of a complete and consistent design space in order to find the optimal solution.

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[24] The sequence seems to be inevitable; however it gains necessity from a rationalistic concept of action only. Following a pragmatist epistemology (like Dewey, 1938), however, it is also rational to go from the specific to the general. This leads to a different interpretation scheme on software development processes, which can provocatively be described as an inverse waterfall model: first an experiment with new ideas in practice, then using that experience to create an artifact as a technical proof of the concept and then reflecting on the entire process by writing down the general rationality of the observed phenomena that emerged in such qualitative experiments. The development of such a Pragmatist conception will be more complex as the simplifying picture of the inverse waterfall model, but the sole aim of the picture is to highlight the specificity of perspective in the waterfall model.

In practice, the waterfall model became the normative standard for judging what is professional software development (cf. Sommerville, 2006). Although one can expect that practitioners – forced by limited time and financial constraints – do not always follow the waterfall approach, it becomes popular to describe the own practice in terms of the waterfall dogma. In becoming the dominant 'interpretation scheme' it shapes reality construction and guides the software development processes in the sense of an 'espoused theory' (Argyris and Schön, 1974).

The dangerous issue with the waterfall model as a dominant dogma is that it makes blind to the evolutionary nature of software. It is the merit of researchers like Böhm or Floyd to point out is this blind spot. At the time when the waterfall model was the dominant dogma, Böhm (1988) published his spiral model and Floyd et al. (1989) published their main work on the already mentioned STEPS model. By presenting alternative interpretation schemes, both Böhm's and Floyd's work constitute landmarks in the reflection on evolutionary software development.

The work on STEPS was influenced by the idea of Participatory Design, and explicitly relies on an evolutionary perspective. It presents a significant step towards a new understanding of continuous development processes in Software Engineering, and demonstrates the interconnection between descriptive and normative interpretations of software practices.

As mentioned above, it becomes usual to describe the own practice in terms of the waterfall model. Empirical observation demonstrated that there is a gap between the 'espoused theory' of the waterfall model and 'theory in use' of development practice. The empirical research reveals that software development in practice often did not follow such a strict linear pattern. In particular, after the delivery of the software product, development typically goes on, and new versions or patches are produced. In the waterfall model, this post-delivery development was subsumed under the residual category of maintenance. This raises the question of whether this observation should be interpreted as 'bad practice', or whether the existing models on software development should be interpreted as 'bad methods'.

At this point, STEPS provides an alternative interpretation scheme of observed practices, arguing that the evolutionary character of software artifacts and post-delivery development was not an accidental, but an essential aspect of software development. The major innovation of STEPS was not to suggest a radically new way to organize software development in practice. As Larman and Basili (2003) demonstrate, one can find examples of iterative developments with short series of 'plan-do-study-act' cycles also in the 1930s. The innovation was to explicate the rationality of the observed practices and provide a new perspective on

the topic. In making the new interpretation scheme explicit it was possible to systematically explore the consequences for managing the continuous software development. The new interpretation scheme also comes along with new normative demands on good software engineering practices. Meanwhile much research has been carried out to improve methods for evolutionary software production that are now standard in agile approaches like eXtreme Programming (Beck, 1999) or SCRUM (Schwaber, 2004). In addition, the improvement of the production means for evolutionary software development had a positive feedback, amplifying the trend of agile software development.

Currently, Google is probably one of the most prominent and successful companies relying on the idea of continuous development. As mentioned before, the search engine seems to be in an “always beta” status.[25] O'Reilly characterizes this radical evolutionary approach also as “perpetual beta". Perpetual beta takes the open source dictum, "release early and release often" to extremes:

> “[A p]roduct is developed in the open, with new features slipstreamed in on a monthly, weekly, or even daily basis. It's no accident that services such as Gmail, [etc. …] bear a "Beta" logo for years at a time. *Real time monitoring* of user behavior to see just which new features are used, and how they are used, thus becomes another *required core competency*” (O'Reilly, 2007, p. 31).

Agile software engineering addresses the issue of continuously evolving software with respect to flexibilization of the software production process, but treats the situated development on the user side as a black box. The question how software products can be made more flexible to support the situated development in the use context is not considered. In the next section, I therefore discuss EUD research, which opens this black box.

2.2 End User Development (EUD): opening the black box of the use context

The invention of freely programmable digital systems was a milestone in the history of the computer and brought the computer as a universal machine into existence.[26] The fluid material of software lead to the vision of easily adaptable software systems allowing end users - at least in principle - to change the behavior of the machine radically in order to make it fit

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[25] In the case of Google, an “always beta“-design philosophy was also supported by the fact that their applications are deployed on own central servers. But also in the case of Eclipse, a well-known desktop application, Erich Gamma used the term “always beta“ in his keynote on the ICSE'05 as one of the development mantras of Eclipse. In the waterfall-oriented interpretation pattern it would be impossible to use such an expression to describe good software engineering practice.

[26] The Z1 was the first functional, freely programmable system, built by Konrad Zuse in 1936.

their own needs. The emerging paradigm of EUD was based on this vision. The research field was defined by the ambition to develop "*methods, techniques, and tools that allow users of software systems, who are acting as non-professional software developers, at some point to create, modify or extend a software artifact" (Lieberman et al., 2006, p. 2).*

This definition is sometimes criticized because of the blurry boundaries between end users and professionals as well as use and development, which leads to the question, whether something should be labeled as EUD or not. However, the fuzziness is not just the outcome of a lack of specification, but results from the efforts of EUD to make these boundaries even more permeable. In this respect, the fuzziness of the definition is quite precise. It broke with concepts in Software Engineering and Human Computer Interaction perceiving design and use not as a continuum, but as completely separate spheres.

A prominent motivation for EUD was given by Henderson and Kyng (1991). They perceive "design as a process [which] is tightly coupled to use and continues during the use of the system". In studying the misfits between the designed artifacts and their use context, they identify three different reasons (a detailed discussion of the different reasons is given in Stevens et al., 2006):

1. diversity of use among a group of users,
2. complexity that prevents a complete anticipation of the use context, and
3. dynamically evolving requirements.

Henderson and Kyng's contribution was to interpret the misfit between designed system and local needs not as an accidental phenomenon which can be overcome by better engineering methods, but as an essential aspect of the evolving character of software artifacts as parts of social practices.

EUD represents a shift in interpreting the evolutionary character of software artifacts on two levels. The first level describes a revision of research perspective that is related to the dominant division of labor, by which realization and appropriation got fragmented. As a result of this fragmentation, IT research has studied the development of artifacts mainly from the production sphere and not from the use sphere. In order to overcome dysfunctionalities that have arisen by the actual form of the division of labor, EUD has been started to explore opportunities to enabling development in the use context. In particular, through the empirical studies we gain a more profound understanding about situated developments occurring in the local context. The second level presents a shift in the understanding of design. The different views on design mentioned above demonstrated that we can study the development from a static or a dynamical worldview.

Table 1 Classification of development conception with respect to their primary design perspective

	Focus on producer's work	**Focus on user's work**
Static worldview	Waterfall development	User Centered Design
Dynamic worldview	Agile Development	End User Development

Based on this differentiation we can construct a 2x2 matrix that illustrates the new perspective on the continuous development introduced by the concept of EUD. The resulting classification of EUD is presented in Table 1:

- In contrast to Software Engineering, the focus of EUD places software development not in the production context, but rather in the use context.
- The focus on the user EUD is shared with other approaches like User Centered Design (UCD).
- In contrast to UCD, the concept of EUD is based on a dynamical worldview. In particular, EUD accepts that software artifacts cannot and should not be designed as fixed and static means-to-end-relationships, as concrete ends can only insufficiently be anticipated during design.
- The dynamic perspective on software as a moving target presents a common ground of EUD and Agile Development
- In contrast to Agile Development, the EUD focus is on how to enable flexibility in the context of the user and not just in the context of the producer.

From such a dynamic perspective, Henderson and Kyng (1991) come to the conclusion that tailorability should be an important feature of software artifacts to enable situated development. This demand leads to a fundamentally new design methodology. For understanding this demand, it is important to recognize the common design practice prevailing at the time building monolithic applications that were difficult to adapt to new requirements. In the meantime, much research and development has been carried out to create more flexible software systems on the technical implementation. As a result of this effort, modern software architectures provide more sophisticated opportunities for tailoring software artifacts in the use context. Particularly in the field of CSCW, several research prototypes have been built as proofs by construction following the principle of radical tailorability (Malone et al., 1994b). Prominent examples for Domain-oriented Design Environment are JANUS (Fischer and Girgensohn, 1990, Fischer et al., 1992), OVAL , Prospero (Dourish, 1995), FreEvolve (Stiemerling, 2000) or CoCoWare (Kruse et al., 2000).

EUD research on tailorable software architectures strongly intersects with research on software architectures for Software Product Lines (Pohl et al., 2005). Both rely on the same idea of flexibilization through composition like component-based software development

(Szyperski, 2002). However, as indicated by Table 1 there is a different focus on the target group. Based on this difference, there is a stronger focus in EUD research about human factors in programming. Moreover the development of ergonomic design environments has been added as an own topic for EUD research. A more detailed discussion of the EUD focus on component based design of tailorable software is given in Stevens and Wulf (2002) and Stevens et al. (2006). In particular, the problem of how to find components which refer to a common meaning and can easily be understood by end users is studied. This work also influenced the development of general design visions as presented in Mørch et al. (2004). It combines McIlroy's (1968) vision of prefabricated software components with Kay's (1977) idea of domain-specific visual components, such end users can assign meaning specific for the respective domain to the technical components.

The elaboration of concepts such as tailorability is based on the insight that software artifacts are subjects of continuous development. This presents a progress against a static view in Software Engineering. Nevertheless, researchers such as Pipek (2005a) have been criticized for EUD research for too narrowly focusing on tailoring only, while neglecting the broader perspective of appropriating. As a consequence of such a narrow focus on tailorability research often omits to see that

> "there is a larger area of technology-related communication, demonstration and negotiation activities aimed at establishing a shared understanding of how a software artifact works and what it can contribute to the shared work context" (Pipek, 2005a, p. 3).

In addition, studying tailoring in isolation, EUD research has a techno-centric tendency to hypostatize flexibility as a value in itself. In particular, reading design studies like OVAL (Malone et al., 1994b) or Prospero (Dourish, 1995) one gets the impression that EUD is simply a technical challenge of increasing flexibility, following the paradigm that more flexibility automatically leads to more - and in this view - better EUD.

Research that follows such a paradigm mainly reduces EUD to a quantitative problem of optimizing the trade-off between enhancing flexibility and dealing with increasing complexity; it thus loses the emancipatory ambition of EUD however.

Such tendency can also be found in the EUD ideal suggested by Fischer et al. (2004). They deduce the EUD ideal from a comparison of all kinds of programming concepts, from office applications, Excel Macros and Agentsheets to general purpose languages such as Java. In order to compare these heterogeneous things in a unique framework, they suggested to use the 'cost of learning' and the 'scope of application' as generally applicable dimensions. Based on these dimensions, Fischer et al. (2004) articulate the EUD-ideal designing EUD

environment: The design should optimize the ratio between the cost of learning and the scope of application, whereby the EUD-ideal has a wide scope with low costs of learning.
Indeed, although being desirable, the EUD-ideal is techno-centric in perspective when defined in such an abstract manner, independent of a specific domain context. The danger of such a perspective is that the simple question what kind of flexibility makes sense in the specific domain context is getting out of sight. In order to prevent such a tendency we should further develop the EUD ideal stressing that an ideal EU -environment should provide the *right* flexibility at the *right* time, in the right place, in the *right* way to the *right* person.
This obviously raises the question how to get to know what the right level of flexibility is. One might argue that in practice this is self-evident, so that the theoretical reflection neglects this issue. However empirical studies on EUD adoption by software producers have shown that (in the meantime) software developers seem to know how to construct adaptable software technically. Rather, the more complex problem is to find out what kind of flexibility is needed (cf. Meurer, 2008, Nett et al., 2008). This non-trivial task cannot be solved just by increasing the tailoring options of an application.

A similar problem in designing flexibility is addressed by Pohl et al. (2005) when introducing a product line strategy:

> "The stability of the domain is also an important factor for the successful […] introduction of software product line engineering. If everything changes every half-year in an unpredictable way, the investment costs never pay off. This situation is similar to not understanding the domain well variability[27]: is added that is not needed and the variability that is actually required is not available" (Pohl et al., 2005).

While Henderson and Kyng (1991) present their reasons for the need of flexibilization from user's perspective, Pohl et al. (2005) discuss the issue of flexibilization as a business strategy from a producer perspective. In combining both argumentations, the point of intersection at which the design of flexible systems makes sense from both a user's and a producer's perspective, is only given in a small area of diverse, but stable application domains. This means that in cases of stable but diverse domains the benefit of a flexibilization strategy is obvious and can be calculated in a relatively reliable manner. In all other cases, Pohl et al. (2005) deny the practical value of software flexibilization.
Although I would not agree with this assessment, one should nevertheless take it as advice for a different look upon on the evolving character of application domains. At this point,

[27] In the software product- line, context flexibility is also called 'variability' (cf. Pohl et al., 2005).

EUD research can draw on literature dealing with the research on appropriation and the question of how it can be linked to systematic organizational change. In their inquiry of organizational change, Orlikowski and Hofman (1997) suggest to differentiate between anticipated, emergent and opportunity-based changes. In Stevens et al. (2006), I discuss the application of Orlikowski's work to the EUD context, arguing that the evolving character of dynamic domains requires that product-oriented flexibilization strategies are supplemented by process-oriented ones (cf. Draxler and Stevens, 2006, Stevens et al., 2006, Stevens et al., 2007).

2.3 Appropriation Research: making sense of software as a cultural artifact

Actually, EUD mainly supports situated development by allowing an easy adaptation of the artifacts' material construction. However, taking construction of meaning into account, Pipek (2005a) has shown that EUD is to limited in scope. Instead, a more appropriate EUD approach should also enable the users in making use of the interpretative flexibility of artifacts and support the situated development changing the symbolic construction.

The symbolic dimension in the construction of technology is also emphasized in Science and Technology Studies. The social construction of technology theory (SCOT), for instance, argues that the evolution of technology does not follow a predetermined path, but rather is subject to interpretative flexibility, leaving room for political negotiations in shaping technology evolution (cf. Bijker, 1995, Pinch and Bijker, 1984).

While SCOT studies technology development from a bird's eye, a posteriori perspective studies on technology-in-use have also drawn attention to situated development affecting the construction of meaning. In these studies, appropriation becomes a key concept to explore the co-evolution of technology and practices in the local context. Appropriation in this sense is interpreted as "work to make things work" (Balka and Wagner, 2006, Pipek, 2005a). It means fitting technology-at-hand into the pre-existing culture and into local patterns of use and life rhythms (Silverstone and Haddon, 1996). Dittrich et al. (2005) provide a good survey on the discourse on appropriation in the field of CSCW.

Due to the close relationship of Activity Theory with the work of Marx (see Section 1.3) one would expect that in Activity Theory oriented CSCW/HCI research would also have introduced appropriation as a theoretical concept. Surprisingly, I could not found any reference to the concept of appropriation in such work. Instead, it was Dourish (2003, 2004), who uses the term appropriation to stress the dual nature of technology as being social and

technical objects at the same time. The term appropriation is specified by Dourish (2003) as follows:

> "Appropriation is the process by which people adopt and adapt technologies, fitting them into their working practices. It is similar to customisation, but concerns the adoption patterns of technology and the transformation of practice at a deeper level."

In his phenomenological work Dourish (2004) adapts Merleau-Ponty's phenomenology to uncover the structure of human-computer interaction. In his work, the role of appropriation (although not systematically elaborated) is to connect the symbolic and the physical dimension of artifacts mediated by the embodied interaction (this being close to my theoretical foundation). Unfortunately he did not further follow the path set by Merleau-Ponty (2006), who describe "the body as the place where […] appropriation occurs" (p. 178).[28] Instead, Dourish (2003) elaborates the concept of appropriation in a way that unfortunately focuses only on the technological side such that appropriability and tailorability become to a large extent synonymous.

Using appropriation as a concept to study situated development beyond the idea of tailorability was mainly done by Pipek (cf. Pipek, 1999, Pipek, 2005a, Pipek and Syrjänen, 2006, Törpel et al., 2003, Pipek and Wulf, 2009). Taking the symbolic dimension of technology seriously, he characterizes:

> "[Appropriation as] a collaborative effort of end users […] to make sense of the software in their work context [… .T]he option of the 'appropriator' to go beyond the rules and ideas that have been originally associated with the thing that is being appropriated" (Pipek, 2005a).

The other notable stream of appropriation research is the IS research on structuration (see Section 1.3). As reaction to the inherent problems of studying technology and organizational development processes from a positivistic stance, the discussion started in the mid-1980s, addressing the question of how structuration theory can be applied in Information Systems research.

In addition, the adoption of Giddens' work also presents an attempt to overcome certain deficits of theoretical debates in IS research where Technological Determinism was pitted against Social Constructivism. Technical Determinism and Social Constructivism – as presented by Orlikowski (1992) – rest on inverse concepts of the constitutive structure of technology. Both are reductionistic attempts, where the constitutive structure relies on one category only. In this view, Technical Determinism is a naturalistic attempt explaining arti-

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[28] I follow this path in my elaboration of the expressive boundary object in Section 4.2.

[30] Cf. Grudin (1994) for a similar classification with respect to different types of software application.

facts by material causes that neglects the symbolic construction or defines it as an epiphenomenon. Social Constructivism, in contrast, is a voluntaristic attempt explaining artifacts by final causes (given by heterogeneous intentions of the interesting parties of a technology) that neglects the material construction of artifacts as an irreducible reality. In structuration terms, both present a dualistic conception of technology, neglecting the duality of technology.

In general, a dualistic conception is confronted with the following problem: if technology determines its purpose, then a further development of the purpose must always go along with a further development of the related technology. The other assumes technology and purposes to be independent from the existing laws of technology. But then, regularities in technology use must be deemed accidental, thereby leaving open the question what the use is good for.

As outlined in Section 1.3, the need for a conception becomes apparent when the artifact does not present a fixed, but a dialectic evolution of ideation and realization of means to an end. In order to characterize the co-evolution of technology, neither the voluntaristic nor the materialistic view of the constitutive structure of technology provides an adequate model of evolution confront an open future.

The debate about the constitutive structure in IS research was interpreted by authors like Orlikowski as homologue to the debate on structure and agency in the Social Sciences. According to Giddens, the antagonistic positions should be overcome by interpreting them as two perspectives sublated in an evolving duality. The adoption of Giddens' work has lead to a variety of theoretical and empirical work in IS research referring to structuration theory. An overview of the various activities can be found, among others, in Jones (1999), Pozzebon and Pinsonneault (2001), Poole and De Sanctis and Jones and Karsten (2003, 2008).

Presenting a substantial survey of the actual discourse for the period of 1983-2002, Jones and Karsten (2003) have identified 225 articles in IS research put themselves into the context of structuration theory. The authors claim that there were "'[t]wo important extensions of structuration theory in the IS context [which] were evident from the literature: Orlikowski's model of technology structuration (Orlikowski and Robey, 1991, Orlikowski, 1992) and Adaptive Structuration Theory (AST) (Poole and De Sanctis, 1989, Poole and De Sanctis, 1992, De Sanctis and Poole, 1994) " (Jones and Karsten, 2003, p. 22). The discourse in IS is therefore mainly based on the work of De Sanctis and Poole and their Adaptive Structuration Theory (AST) (cf. Poole and De Sanctis, 1989, Poole and De Sanctis, 1992, De

Sanctis and Poole, 1994, Poole and De Sanctis, 2003), and on Orlikowski's model of technology structuration (cf. Orlikowski, 1992, Orlikowski and Robey, 1991, Orlikowski, 2000).
As mentioned already, De Sanctis and Poole directly refer to Marx's concept of appropriation, by quoting Ollman's (1971) work on Marx as their primary source. They extracted from Ollman the main tenets of Marx's concept, namely that appropriation is part of the formation process which shapes both subject and object simultaneously; that the subject of the formation process is the individual as well as the society as whole, and that the object is shaped collectively by nature and culture:

> "They [Marx and Hegel] were concerned with how humanity progressively learned to control and shape the natural world and how this, in turn, influenced and enhanced human society. The nature of subject-object relationships were of utmost importance in understanding this progression. For Marx, who emphasized the productive and self-constructing nature of humanity, the concept of appropriation was the key that unlocked the nature of subject-object relationships. To appropriate an object was to use it constructively, to incorporate it into one's life for better or worse (Ollman, 1971). It was of the nature of men and women to make their worlds through appropriation: *objects, and advances in modes of appropriation had laid the groundwork for advances of human society*.
>
> According to this perspective, every effect of a technology, including a GDSS, depends on appropriation of the technology. The subject-object relationship cuts two ways. In appropriating an object, the user realizes that object (Ollman, 1971). As both Marx and the Pragmatist philosophers noted (Mead, 1983), what any object is depends on how it is used or how it enters into human activity. This implies that the realization of any object may differ across cases and that *the object itself can change as people change their mode of using it.* […] Marx's idea of appropriation as constructive use [is] that [it] *shapes both user and object"* (Poole and De Sanctis, 1989, pp. 150)

At the end of exploring the origins of the term, they conclude that "Marx's basic understanding of appropriation provides a sound starting point for an analysis of human use of information technology" .
As mentioned in Section 1.3, adopting Giddens' Structuration Theory, De Sanctis and Poole argue that in this process technology is a mediator and outcome of social practices at the same time. In a further elaboration of the Adaptive Structuration Theory, they argue that technology must be appropriated and therefore there is no a direct, causal influence on human behavior. Rather, the observable outcome is determined by the patterns of using the technology, which is a result of the appropriation of technology.

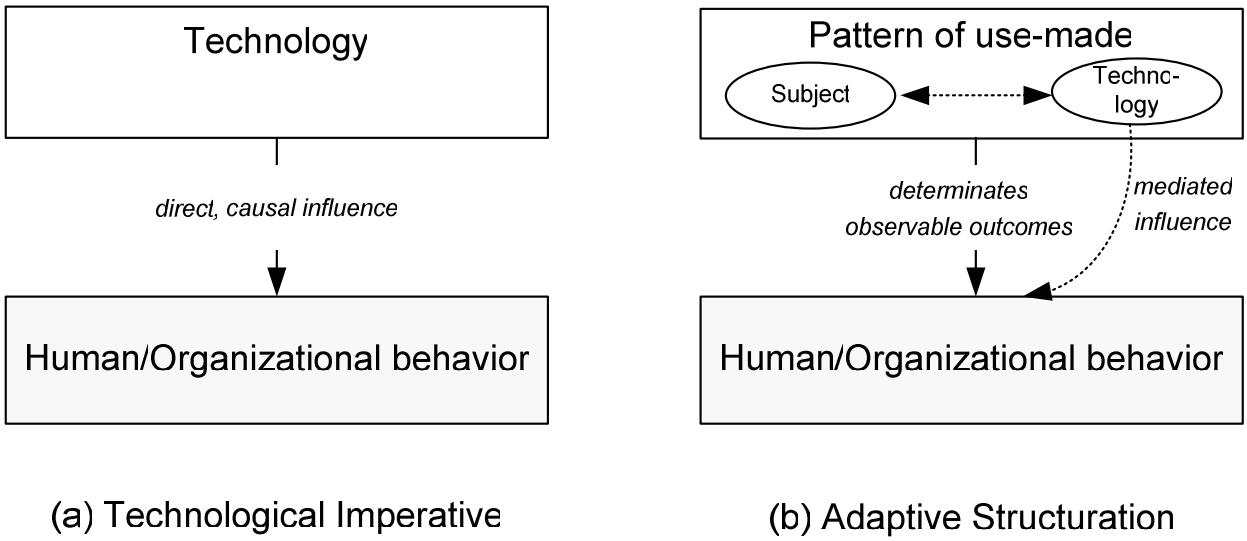

Figure 5 The traditional theoretic position of the Technology Imperative (a) and the shift in the underlying theoretic conception provided by AST (b).

In Section 1.3, I outlined that De Sanctis' and Poole's use of the appropriation concept has an idiosyncratic flavor as they conceive of a dialectical constitution of technology, but use the term in a positivistic reductionistic way. This leads to a critique of the appropriation concept in general (e.g. Orlikowski, 2000, Pipek, 2005a, Jones and Karsten, 2003, Jones and Karsten, 2008, Jones, 1999). In particular, Jones and Karsten accuse that De Sanctis and Poole of presenting a reified model of structuration through the adaptation of underspecified concepts like 'appropriation':

> "The extra concepts, such as *spirit* and *appropriation*, employed by AST would also appear to reify what for Giddens are purely analytical constructs" (Jones and Karsten, 2008, p. 146).

However, in reaction to this reductionistic tendency in AST, a new variation of the previous debate on the constitutive structure of technology arose. In this new debate, it was discussed if structure is being embedded in technology, or if it enacted in using technology (cf. Orlikowski, 2000). In Section 1.3, I have demonstrated that this debate can be prevented if we take the dialectic nature of the appropriation concept seriously. In such dialectic view, the debate on enactment juxtaposing appropriation is insofar misleading, as isolating technology *from* social practices suggests that material and symbolic reality exist as separate entities and not being a dialectic unity that are formed in cultural-historic processes. Further I also argue – in opposition to Jones and Karsten – that neither the dialectic appropriation concept nor De Sanctis and Poole's initial reception of this concept can be made responsible for this reification tendency of AST. As demonstrated in Section 1.3, this tendency is due to a reductionistic use in AST as a result of a positivistic research interest in De Sanctis and Poole's work.

The most notable streams of appropriation research outside IT research are Critical Theory and the Cultural Studies as mentioned in Section 1.4.2.

Cultural Studies stand in a Marxian tradition (Hall, 1980), but they are also influenced by de Certeau's (1984) notion of appropriation as resource of bottom-up power responding to structures of domination in society (cf. Poster, 1992). Therefore appropriation presents not only a theoretical construct in the Cultural Studies, but it is also used as a political term, which introducing a distinctive feature against a mainstream, 'uncritical' media theory and reception research:

> "The various work carry out in this field [of appropriation research] have in common that they do assume that media use is a >takeover< or >assimilation< process of a certain media content – a picture which is traditionally expressed by the term of *reception* – but a process of >take possession of it< of media content. This process of appropriation of media content is a mediation process between media content – which is localized in specific discourses – and everyday life contexts of the user – which are also discursively mediated" (Hepp, 2004, p. 165, translation by the author).

One of the characteristics of Cultural Studies is to emphasize the active role of the consumer, which leads to a renaissance of the term 'appropriation'. In their survey of Cultural Studies, Barker and Willis (2008) highlight the existence of *creative consumption*, where users are not passive, but play an active, creative role in the symbolic production of the artifact. In particular, the political stance sensitizes researchers to explore in detail the appropriation practices of consumers in everyday life as a kind of *production-in-use* (Storey, 2006).

Typically, Cultural Studies focus on appropriation of media products (such as TV shows or music), however some studies also deal with the appropriation of other types of technology (cf. Eglash et al., 2004). In particular, the study of the Sony Walkman by du Gay et al. (1997) provides a sophisticated theoretical framework for cultural artifacts, whereby appropriation is a part of cultural consumption and embedded in the cultural circuit. Moreover, the research on consumption practices carried out by Cultural Studies makes one aware that communication is not an additional, but an essential part of appropriation (cf. Karnowski, 2008, Holly et al., 2001). For example, Hepp (2004) states that communication serves as a catalyst for appropriation in the social context.

Another stream of thought on consumer side of products is provided by the Critical Theory and its research into the cultural industry (cf. Horkheimer and Adorno, 1997, Adorno, 1998). They did not directly rely on appropriation as a theoretical construct, but focus on its counter-part, the concept of alienation. As outlined in Section 1.4.2, Cultural Studies and Critical Theory differs in respect to the question whether situated development is explored

in terms of social-material conditions, or in terms of opportunities to create situated innovations from the provided material. I come back to Critical Theory in my survey of Marx's concept of appropriation in Chapter 3.

In summary, the term appropriation is not used homogenously in the diverse streams of appropriation research. However, common to all these studies is that the use of the term appropriation denotes the active role of the user in constructing the artifact as an element in a local context. 'Appropriation' and 'adoption' refer to similar phenomena, but from a different theoretical stance. Static and atomistic theory conceptions perceiving artifacts as fixed and isolated entities prefer the term 'adoption'.

The term 'adoption' is typically used in the positivistic innovation research paradigm (see also Section 1.3). For example, in the Diffusion of Innovation theory (DOI) (Rogers, 2003b) and its adaptation in IS research (e.g. Fichman, 1992), the term adoption denotes the point where people start to use an innovation. The positivistic paradigm does not reflect, however, on the evolution of subject and object both being shaped in the process of appropriation (cf. Stevens et al., 2009b). The mechanistic view on adoption, where consumers play a passive role is also the outcome of a "pro-producer-", or as Rogers (2003b) notes, "pro-innovation" bias. According to this comprehension, innovations are made by designers of an artifact, and not by users. This ignorance of the situated nature of innovations is supported by the production-oriented view of artifacts as objects only made by professionals.

In contrast, 'appropriation' is often used by dynamic and holistic theory conceptions, which perceive artifacts as co-constructed by the socio-cultural context (cf. Pipek et al., 2008). Here, the consumption-oriented view of artifacts as *objects used by man* helps to understand to change the construction of meaning, so that creative potential of situated development become more evident. This issue can be further illustrated by the following example: A stone, which is (from a material perspective) not made by man, becomes an artifact when a subject recognizes this stone as a tool in relation to a need for hammering. In this moment, the stone changes its character, becoming an artifact by altering the meaning of the object. In this example, it becomes evident that symbolic construction is constitutive of artifacts, and it is demonstrated that sense making is an essential aspect of the continuous development process. An important contribution of appropriation research is to make us aware of this aspect.

The majority of technology-in-use inquiries in Cultural Studies as well as in IS research have an analytical focus supporting the understanding of or even predicting of appropriation

phenomena. In particular, they uncover practices of generating meaning in situated development.

They do not address the challenge to support the user in making sense of the artifacts-at-hand. However, the empirical and theoretical research on use practices supplements constructional research, as they provide a theoretical background for elaborating on Pipek's (2005a) considerations on supporting the construction of meaning in the situated development of technology.

Following Pipek's conception, software design should support end users in making use of the interpretative flexibility in much in the same way as tailorability supports end users in making use of the material flexibility of the artifacts. With the concept of Use Discourse Environments, he presents a design approach supporting user communities in appropriation work. With this respect, Pipek has proposed a list of requirements to support user variation in the symbolic constructions of artifacts:

- supporting the articulation work, making the 'historicity' (Pipek, 2005a) of the artifact visible,
- supporting the negotiation of usage conventions,
- enhancing the means for co-user observation by providing means for demonstrating usages to others,
- enhancing interpretative flexibility by providing means for exploring alternative interpretations without risk.

Analytical work on appropriation such as the exploration of the meditation structures needed to make breakdowns and situated innovations accountable helps to frame problems to which Use Discourse Environments are a promising solution. In particular, analytical research helps to shape design spaces such that Pipek's can be applied in a generalized way if we study it in the broader context of mediating appropriation and production work.

As mentioned in Section 1.2, the Appropriation Infrastructure is such a generalization of the core idea of the Use Discourse Environments conception. The broader context is delivered by Marx's conceptual synthesis of the sensual and the social dimension of appropriation and his strategy to interpret consumption and production processes in society. The next chapter presents an outline of the semantic field that is generated by such an understanding of appropriation.

3 Dialectic origins of appropriation work

In the previous chapter, I developed the idea of software as an evolutionary product from a Software Engineering perspective. In addition, I have demonstrated that in Software Engineering different approaches have been suggested to support the evolvability of software in different dimensions, e.g. applying agile development or designing tailorability. Moreover, we have seen that the concept of appropriation has been adopted in research as a sophisticated analytic tool to study local innovations as a co-evolution of artifacts and social practices.

In the following, I elaborate on the semantic field that is spanned by an emphatic view on appropriation. In particular, I demonstrate in this chapter that the concept of appropriation can be understood as an analytical category developed out of Marx's evolutionary anthropology. This interpretation was shaped by Márkus' (1978) suggestions on Marxian anthropology as well as the philosophical study of Röhr on appropriation and personality. Particularly, I also take Ollman's (1971) 'Alienation: Marx's Conception of Man in a Capitalist Society' into account. In addition, my interpretation emphasizes the Romantic roots in Marx's work, as outlined by Taylor (1977) and Honneth (1995).

Regarding my research topic, I am primarily interested in Marx's conceptual synthesis of a micro and a macro perspective on appropriation work. The intention is to arrive at an analytical tool for studying situations in which innovations emerge to solve a specific wicked situation, but in doing this to create a seed of innovations that are of general interest. The ambition is therefore to integrate a situated perspective on in-situ design with a social perspective on the division of appropriation and production work.

Against this background Marx has become a highly interesting theorist, as his emphatic concept of appropriation and labor has aesthetical roots in an expressive nature (see Section 3.2), but his major input concerns the modern forms mediating production and consumption (see Section 3.3). Interpreting his notion of appropriation as an analytical framework (see Section 3.4) makes it possible to study both ends without falling back into the simplistic reductions mentioned in the theoretical IS debate on structuration of technology. This is accompanied by a different role for social research (where design research presents a special form). The role of analysis regarding social practices is not just prediction, but providing a discursive critique which is freed from the immediate pressure to act in figuring out the general rationality which has been expressed in a situated development. This scien-

tific stance shapes my reception as well as my presentation of the Marxian appropriation concept.

In addition, this chapter also has a methodological function in my thesis. As an interdisciplinary work, my intention is to integrate the IS (or macro), the CSCW (or meso) and the HCI (or micro) perspective on distributed evolving software artifacts.[30] For this attempt, Marx's emphatic concepts of labor and products are also relevant from a methodological point of view, as they integrate 'sensuality' (as a micro level concept) and 'sociality' (as a macro level concept) seen as two different, irreducible qualities to analyze means of production.

Therefore, the presentation also attempts to reconstruct the development of different qualities emerging from the free interaction of man and nature. In doing so, the presentation also prepares the argumentation of Chapter 4, which adapts the analytic perspective of an evolutionary anthropology to elaborate Fischer's remark concerning the different roles of artifacts serving as boundary object. Last, but not least I also include in this chapter several 'paraphrase'-boxes that draw on the relationships between the Marxian conception and the actual debate on appropriation in IS and CSCW research.

3.1 Origins of the concept of appropriation

The historic-cultural origins of appropriation as a theoretic concept go back to the end of the 18th century (cf. Braun, 2004, Keiler, 1990). At the time, the term appropriation (Aneignung) was used by jurisprudents in discussing general questions of property and possession. Hegel introduced the concept of appropriation to philosophy, precisely as the concept became part of a philosophy of law. Marx and Engels took up these philosophical considerations, but gave the term a materialistic interpretation. They elaborated the concept of appropriation as part of their effort for describing relationships between the ownership structure of society (gesellschaftliche Besitzverhältnisse), political-cultural processes and personal development (or development in general, respectively) (cf. Braun, 2004, p. 19).

At the same time, philosophers such as Schleiermacher worked out a pedagogic-psychological interpretation of appropriation as a part of their theoretical work on self-formation and education. In the 20th century, it was mainly the Activity Theory respectively the Cultural-Historical School[31] in psychology (both rooted in Marxian tradition) which fur-

[31] Internationally, the most prominent opponents of the Cultural-Historical School would be Leontjev and Vygotsky; in Western-Germany it was primarily the Critical Psychology, promoted by Holzkamp, who made Leontjev's ideas popular.

ther developed the concept. The evolutionary character of the concept of appropriation can further be observed in the field of pedagogy where the term 'appropriation' undergoes a renaissance. In addition, this trend is fostered by the activity of the society of International Cultural-historical Human Sciences.

The theoretical foundations of definitions of an emancipatory education in Marx's evolutionary theory are according to the textual sources closely related to the concept of product as objectification of labor. In this point, Marx's philosophy is influenced via Hegel by Romantic expressive anthropology (see Section 1.3).

The common origins of evolutionary and expressive anthropology are rooted in the Romantic notion that in reflection, man abandons the nexus of immediateness. This presents a constitutive act by which man becomes both natural being (Naturwesen) and rational being (Vernunftswesen). It transforms man into a universal being, but at the same time his freedom for reflective acting separates man from nature. Following expressive anthropology, the freedom of the Enlightenment is thus linked to personal alienation, yet the moment of alienation cannot be overcome in a true sense by returning to a previous state. Instead, the separation of man and nature should be sublated in a Hegelian sense in the ideal that the human (both as individual and as genus) recognizes his being in nature while expressing himself in nature.

Hegel took up this idea placing crucial importance on labor as self-creation of man, and which was in turn further elaborated by Marx. Taylor characterizes Hegel's conception as follows:

> "At the same time man in acting on external nature to serve his purposes, in working, helps to transform it and himself, and to bring both sides towards the eventual reconciliation" (Taylor, 1977, p. 120).

The theory of Expressivism is closely related to an empathic understanding of practice and human action, where action has a productive quality, transforming nature to the own intent, but also as formative quality. Expressive nature is both, a mode of world disclosure (*Welterschliessung)* and of authentic self-expression.[32]

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[32] This aesthetic moment of self-awareness through expression has several linkages to Peirce's consideration of abduction as a weak form of reasoning. Following Chiasson (2005), Peirce has described in one place abduction as the aesthetic process of musement.

From a logical point of view, aesthetical experience and abductive reasoning are related forms of reasoning because they are - categorically spoken - closest to the *present in general* which is mediated by situated boundary objects. In design research, they are related to the concept of reflective technology development (see Section 1.2) and Bernhard Nett's notion of design research as qualitative experiments (cf. Nett and Ste-

Romantic expressivist anthropology stated that:

> "[O]ur life is seen as self-expression also in the sense of clarifying what we are. This clarification awaits recognition by a subject, and man as a conscious being achieves his highest point when he recognizes his own life as an adequate, a true expression of what he *potentially* is - just as an artist or writer reaches his goal in recognizing his work as a fully adequate expression of what he wanted to say. And in one case as in the other, the 'message' could not have been known before it was expressed. […] The specific property of human life is to culminate in self-awareness through expression" (Taylor, 1977, p. 17).

This outlines the historical background of the ideas underlying my artifact concept as a dialectic unity where the artifact present-at-hand present-at-hand is a meaningful object that represents a related socio-material construction.

As introduced in Section 1.3, the idea of expressive nature emphasizes the categorical difference between the material object that appears in the present and its conceptual determination. An artifact has an expressive nature insofar as it embodies ideas. Ideation and realization are two moments of dialectic unity, while any contradiction between them is a force for further development. In expressive anthropology, this dialectic is not just a residual aspect but rather a condition for the possibility of experience.[33]

Recalling Chapter 1, Marx transforms the Romantic dialectic of the self, which culminates in motives of a genius, into a mundane variant by considering the conditions of economic production in capitalism. He appropriates the Romantic dialectic of self-expression in and through nature in his concept of objectification as an analytical as well as a normative idea. In Romanticism, the ideal of life was to realize oneself by means of authentic self-

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vens, 2008). A discussion of expressive aesthetic theories and modern hermeneutical as well as materialistic aesthetic theories, and the relationship to Peirce's abduction concept is given by Pilz (2007).

[33] Traditional HCI theories, which are mainly based on a naturalistic conception of human behavior, do not provide an appropriate vocabulary to address the constitutive elements of the artifact in its presence in the formation of the subject. In this point, aesthetic theories, which are grounded in the field of art and humanities, provide a more elaborate framework to address the issue in. From such an aesthetic perspective, the artifact would not just be a mapping of an existing mental model onto the material expression. The artifact is not just the realization of the designer's intention. Instead, the idea also emerges in the appearance of the artifact (see also Section 1.3).

This presents a fundamental difference to classical conceptions in requirement engineering or cognitive science -oriented HCI theories. An example for such a theory is Norman's (1986) conception of cognitive engineering. He conceives the artifact solely as the mapping of a mental model of the designer, neglecting the constructive element of perception in the formation of intention. In opposition to such a perception, the design professor Stephan (2001) takes up the idea of »thinking on the object« from the designer Otl Aicher. He argues that the design artifact plays the role of an epistemic object, whereby thinking is related to perception (Anschauung) and emerges from doing.

expression. At the time, the dialectical conception of appropriation of nature and realization in nature was mainly conceived from the perspective of personal self-development, and the arts were considered to be the primary realm for this form of life (cf. Taylor, 1977, p. 17).
This idea was further elaborated by Hegel. He perceived in the expression of man in nature the option to sublate the separation of man as a natural being and man as a rational being. His aim was to reconcile man and nature by the ideal of a well-done expression. A well-done expression overcomes the contradiction between the subject's intent and the object's constraints, by re-defining, on a higher level of freedom through the capacity of understanding the necessity. This means, it keeps the autonomy of subject and object, but at the same time it resolves the separation between freedom and necessity to the degree that a well-done expression can provide a sublation of subject and object.
Marx's merit in extending Hegel's thinking was to generalize the pre-industrial, tendentially elitist and exclusive attitude towards art ideals of Romanticism, and generalize them to any every kind of labor: man is constituted by labor as the realization of man in nature through the appropriation of nature. Labor also plays a central role in evolutionary anthropology, because by labor man and nature will be transformed. Moreover, Hegel's idea of objective contradictions as a force in history is also present in the concept of labor, in which the dialectic of appropriation and realization presents a contradictory unity that is the driving force of progressive development (cf. Taylor, 1977, p. 133).
With these considerations on the expressive and evolutionary nature of man in mind, Marx studies the history of societies. He perceives the industrial revolution as a central period in human history, figuring out the new opportunities revealed by this historical moment. But at the same time, he studies the impact of class domination within the production conditions on the expressive function of labor, thereby developing his concept of alienation, fragmentation of experience that leads to a reification of labor (Verdinglichung von Arbeit).
Marx mainly conceives industrial products as reifications of alienated work. Domination of the means of production meant at Marx's time that products were no authentic expression of work, as workers were separated from the means of production, and products reduced to their exchange value, neglecting the value of their use value. However, this negative characterization is only possible against the background of the positive determination of products, even the case that in history we do not find any example of an authentic expression. Instead it presents an anticipation of perfection given by the counter-factual concept of the objectification of labor, which keeps the essential of the Romantic ideal of life as authentic self-expression.

In particular, in his text “The Alienation of Labour” Marx develops an emphatic understanding of labor from an anthropological perspective. There, Marx perceives man as a natural being which lives as a ‘limited creature’ in and from nature. Man shares this aspect with every other biological creature in the world. But as Márkus (1978) points out, man can be characterized as a universal natural being.

> “Species-life, for man as for animals, has its physical basis in the fact that man (like animals) lives from inorganic nature, and since man is more universal than an animal so the range of inorganic nature from which he lives is more universal” (Marx quoted from Fromm, 2005, p. 83).

The element of universality makes not only a quantitative, but also a qualitative difference, which leads on to a theoretic conception that can be characterized as a negative anthropology by Marx: man’s specific property is that there is no specific essence, but a universal potentiality. In other words: the specific character of man is not his being (Sein) but his potentiality of becoming (Werden). From this position, Marx characterizes man as a species (Gattungswesen) in this way:

> “Man is a species being, not only because in practice and in theory he adopts the species as his objects (his own as well as those of other things), but - and this is simply another way of expressing it – but also because he treats himself as the actual, living species; because he treats himself as a *universal* and therefore free being. […]
>
> The universality of man is in practice manifested precisely in the universality which makes the all nature his *inorganic* body – both inasmuch as nature is: (1) his direct means for life, and (2) the material, the object, and the instrument of his life-activity” (Marx, 2007, p. 90).

Marx’s historical anthropology is rooted in the potentiality of becoming. This idea means that the subject is constituted by and through historical processes, which will never be reaching an end due to the universal human potentiality. At the same time, it is human duty to actively make use of his universal potentiality by making history. Humans make and must make history by virtue of their natural constitution. Therefore, labor is the way to change nature through the man’s bodily being-in-the-world (Leiblichkeit) of man.
In a first definition, labor is grounded in and refers to this bodily being-in-the-world. Through labor, embodied man is connected with the world; moreover, labor is a constitutional element of living in the world:

> “Labor is, first of all, a process between man and nature, a process by which man, through his own action mediates, regulates and controls the metabolism between himself and nature” (Marx, 1992, p. 283).

Human’s subsistence is only granted through his own activities, by changing nature according to its laws. Humans share this existence with all other natural beings (e.g. animals or plants). To say that humans depend on the law of nature, however, does not mean that

their activities can be accurately described in purely naturalistic terms (which might be possible in the case of other natural beings). Although primitive, instinctive forms of life can be reduced to cause and effect, the specific quality of labor is to refer to an intention in which man does not solely rely on nature, but makes conscious use of it:

> "He confronts the materials of nature as a force of nature. He sets in motion, his embodied nature forces, his arms and legs, head and hands in order to appropriate materials of nature in a form, which is suitable to his own life. Through his movement, he acts upon external nature and changes it, and in this way simultaneously changes his own nature. By thus acting on the external world and changing it, he at the same time changes his own nature. He develops his slumbering powers and compels them to act in obedience to his sway" (Marx, 1992, p. 283).

In this characterization of labor, Marx tries to avoid a dualistic position which splits man into a mental and a natural being. Instead, the mental and the natural create a dialectic unity sublated in labor.[34]

In addition, Marx's concept of labor emphasizes that labor is not just a way of changing nature, but that nature is the material for realization (Verwirklichung), while in the anticipation of perfection products becomes objectifications of labor (Vergegenständlichung). The aspect of intent also refers to the fact that physical and mental factors are equally incorporated in the objectification of labor: "Just as head and hand belong together in the system of nature, so in the labor process mental and physical labor are united" (Marx, 1992, p. 643).

In humanizing nature, "man's relation to nature becomes more and more complex and free from fixed biological restraints, but it loses progressively its one-sidedly *utilitarian* character" (Márkus, 1978, p. 12). In this process and as a consequence of the dialectic of need, power and production, man becomes more and more universal in his relations to nature – both quantitatively and qualitatively (cf. Márkus, 1978, p. 12). In cultivating nature, man as a species cultivates himself:

> "It is just in his work upon the objective world, therefore, that man really proves himself to be a *species-being*. This production is his active species-life. Through and because of this production, nature appears as *his* work and *his* reality. The object of labor is, therefore, the *objectification of the man's species-life*;

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[34] We found the mental and the natural creating a dialectic unity in Activity Theory. In the dialectic of internalization and externalization, consciousness and activity form a unity, in which the separation of subject and object is an outcome of reflection. In Pragmatism, we find a similar notion, namely that subject and object present a dialectical unity. For example, in his thoughts on the present as locus of reality, Mead wrote "The reflection of the organism in the environment and the reflection of environment in the organism are essential phases in the maintenance of the life processes that constitute conscious intelligence" (Mead, 2002, p. 39). From such dialectic perspectives, volition and determinism are perceived as belated and reductionistic abstractions.

for he duplicates himself not only as in consciousness, intellectually, but also actively, in reality, and therefore he contemplates himself in a world that he has created" (Marx, 2007, p. 91).

Parenthesis: Marx's anthropology is compatible with demands for a theoretical concept to reflect upon the material and meaningful constructedness of artifacts. It allows us to conceptualize artifacts as a dialectical unity of mental and natural objects grounded in the dialectic relationship of rational and natural being as the constituent of man.

Marx applies the conceptual elements of his historical anthropology to the field of human needs, thus revealing their evolutionary character. In respect to the difference between natural and species beings, Marx distinguishes between 'natural' needs representing a kind of deficit, and 'species' needs representing a kind of passion. Based on the potential of human beings, 'species' needs inherit the potential of progressive growing – not only in quantity, but in quality, while the formation is grounded in concrete socio-historical processes:

„Just as only music awakens in man the sense of music, and just as the most beautiful music has *no* sense for the unmusical ear – is [no] object for it, because my object can only be the confirmation of one of my essential powers and can therefore only be so for me as my essential power is present for itself as a subjective capacity, because the sense of an object for me goes only so far as my senses go […] - for this reason the *senses* of the social man *differ* from those of the non-social man. Only through the objectively unfolded richness of man's essential being is the richness of subjective *human* sensibility […] either cultivated or brought into being. For not only the five senses but also the so-called mental senses, the practical senses (will, love, etc.), in a word, *human* sense, the human nature of the senses, comes to be by virtue of *its* object, by virtue of *humanised* nature. The *forming* of the five senses is a labor of the entire history of the world down to the present" (Marx, 1987, p. 301-302).

Another more recent example of appropriation is given by Pipek (2005a, p. 16). He describes his own personal experience of the appropriation process of mobile phone technology. During the mid-1990's, he refused to engage with the emerging mobile technology. In autumn 2001, he bought his first mobile telephone, although he did not observe significant progress in the technology's evolution. Therefore, it was not an improvement of technology that changed his attitude, but two situations he experienced. In the first one, he observed how a friend prevented an ordinary car-parking problem by means of mobile technology. In the second one, he became aware of mobile technology's capacity to carry out additional work while driving his car. He concluded that in this process of appropriation, the general usefulness of technology provides an important prerequisite, but, moreover, it was the perception of "interesting usages" of this technology.

Using the Marxian terms, this can also be described as the development of the power or competence to utilize mobile technology constructively by (anticipating) its incorporation into one's own (anticipated) practice.

The example given by Marx is instructive in that it highlights several aspects of Marx's theory of appropriation. Ollman (1971, p. 90) uses this example of Marx to discuss the connection between man's power and this environment, providing the needed objects to realize a power. More specifically there will be a close correspondence between form, the level of appropriation and the state of the object concerned. The example also illustrates that appropriation is a force in and an outcome of the history of man as a species being.

In addition, the example presented by Pipek (2005a, p. 16) can be interpreted from a Marxian perspective as an illustration of the dialectics of need and power. In the process of appropriating mobile phone technology, the increase of power (the competency) in using mobile technology is inseparably interwoven with the growth of a need for mobile communication. Moreover, the process itself is embedded in an evolution of the practice as a whole.

While the example of Pipek presents appropriation as a formation process from an ontogenetic perspective, Marx gives an example from a phylogenetic position, so that in the formation of objects and subjects, their entire history is present. Although both examples describe formative processes on different levels, they share the same structural characteristics. One of these common characteristics is that neither subjects nor objects posit an essence, but a potentiality, which is formed by history. Another characteristic is that the formation not only refers to nature, but also to culture and society. In particular, they are open, but as development process they posit a necessity for retrospective reflection.

Parenthesis: The evolutionary anthropology of Marx offers theoretical concepts which could allow reflection upon the dynamic character of needs. Moreover, Marx's thinking with regard to the dialectics of power and needs can be read as a theoretical generalization of Pipek's (2005a) observations on technology appropriation.

Needs and power are not just naturally given, but also a result of cultivation. There are therefore no naturally fixed separations of subject and object, but the subject is itself an abstraction in reflection on an existing world-disclosure.

Following Marx, the object-subject relationship can neither be reduced to the natural nor the individual. Instead, objects are disclosed in and through communities, in which, indeed, the objective laws of the object enforce its determination. However, this is just one element. At the same time, the determination of the object "is given by man and by the laws of the concrete social development. In the objective of the object, the laws of nature and society op-

erate collectively" (Röhr, 1979, p. 63 - translated by the author). In particular, objects as human products have therefore a 'material content' and a socio-historically created utility; moreover, they have a 'social form' and "in social life human products function not only within a network of rules that define the mode of *technical use* […] but also in a network of social relations which define the conditions and character of their *social employment*" (Márkus, 1978, p. 20).

It is often neglected in a non-dialectical position that the transformation of nature given by the dialectics of appropriation and realization does not only mean that nature is subordinated by man, but in a reciprocal manner man has to subordinate himself under the laws of nature. Both Röhr and Márkus (1978) reflect on consequences of this dialectical position. They argue that the subject comes only into being in and through appropriation of and realization in the world, while the genesis of the subject is always an expression of the dominated socio-material conditions.

In particular, appropriation and objectification are always linked to sociality, whereas "[s]ociality, even in its most elementary forms, presupposes as its universal preconditions the existence of two further systems of rules and objectification patterning the everyday life and intercourse of individuals: that of *language* and of *custom* (in the narrower sense of the word)" (Márkus, 1978, p. 63). In turn, language and customs in their concrete realization are also products that have been appropriated through practical socialization.[35]

Dialectical thinking occurs not only in the development of artifacts, but also in the development of the self. Outside of socio-material practices, there does not exist any subject, although the subject cannot be reduced to these practices either. Therefore, the self needs to be considered as the product of socio-material practices being dialectical in nature:

> "Two remarks are called for here. First, the socio-historical conditions which determine the concrete individual are not to be conceived as fetters alien to him and externally imposed upon his real, 'primordial' impulses and drives, thereby stifling and repressing his authentic self. They are the real, internal conditions of his individuality, i.e. conditions appropriated and internalized by him, turned into constituents of his own personality […] Second, it would be a gross error to identify the Marxian conception of the socio-historical determination of individual with the presupposition according to which each concrete human personality can be fully resolved into, and reduced to, a multitude of sociological (or sociological *and* biological) determinants, that it has to be understood as the simple resultant of their interaction. Man is not a passive *tabula rasa* which simply suffers and registers the impression made upon him by his social milieu. The material and ideal 'elements' of his objective social world become transformed into constituents of his

[35] This is the main focus of the research by Vygotsky and Leontjev.

own personality […] only through the process of *appropriation*, i.e. only through and due to, his own selective activity" (Márkus, 1978, pp. 21)[36]

This means that in the formation of the subject through appropriation, the material and conceptual world of the (social) environment become an inseparable part of the self. A result of this argument is that firstly the subject – along with her needs and power – will only be completely aware of herself if she is entirely aware of the conditions of her (social) environment. Secondly, the awareness of the self is only mediated through participation in social practices. Consequently, the emancipated subject is not the primordial natural being, but rather transcends existent circumstances by appropriation of these circumstances as social subject.

This also means that the content of appropriation can neither be anticipated internally nor determined externally. The rationale linked to appropriation is not naturally given, but it must be determined in and by appropriation itself. Therefore, according to Röhr , the moment of appropriation is always accompanied by the creation of meaning. However, according to Röhr meaning is not a psychological, but a social category, as it is always influenced by existing social conditions and provides a tool for the discursive creation of rationality in a normative sense, so that meaning cannot be adequately described by a psychological (or naturalistic) vocabulary alone.

This is the reason why Röhr argues that although appropriation and learning must be concertedly considered, the concept of appropriation and the concept of learning will not merge completely:[37] With respect to behavioral as well as cybernetic learning theories, the goal of learning is to change behavior.[38] However, little is stated about behavior and its change in empirical categories, specifically with regard to its social meaning as well as to the development of the subject and the expression of its personality. Since appropriation is not determined by its form but by its content, it cannot be solely understood psychologically or else it would be reduced to an individualized interiorization . Appropriation contributes

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[36] In this paragraph, the similarities to the pragmatic conception of the self as a social process (elaborated by Mead) become obvious. Mead perceives the self as the contradicted unity of I and Me, thereby describing the dialectical relationship between society and the individual (cf. Mead, 1983). The I presents an embodiment of the logical concept of here-and-now, which I introduced in Section 1.4.4 The relationship between the theoretical foundations of the philosophy of Marx and Mead is discussed in Müller (1983) as well as Bernstein (1971).

[37] Röhr criticizes that as a psychologist conception, Activity Theory sometimes reduces appropriation to a cybernetic learning theory.

[38] In his work, Röhr mainly reflects cybernetic conceptions of psychology.

therefore relates to knowledge development not just in an instrumental sense (gaining skills to reach goals rightly), but in emphatic sense of enlightenment (gaining rationality to follow right goals). This means in particular that knowledge development has to be interpreted in this context from the perspective of a self-critical social practice, not from a psychological point of view.

While the aspect of learning emphasizes the formation of the subject, one should not neglect the formation of the object. Appropriation can only come into being by means of labor, in which appropriation and realization constitute a dialectic unity. In this sense, Röhr points out that the actual realization of an intention in the product of labor is the essential moment in the appropriation of nature:

> "Labor is in a specific sense the transformation of the form of natural objects. Appropriation of nature through labor means to subordinate processes of nature under the goals of humans, and application of them according to these goals respectively. The essential moment in the appropriation of nature is given by the actual realization of human goals through the product of labor. This presupposes not just the cognition of the objective law of nature given by the object, but within the work process also the subordination under these laws" (p. 46 - translated by the author).

Appropriation is therefore given by a triadic determination of realization (Verwirklichung), cognition (Kenntnis), and recognition (Anerkennung), where realization means to have the cognition of the intention and the laws of nature given by the object. Moreover, since action is always infected with the recognition of both, the intention and the laws of nature as one become responsible for the outcome.[39]

This is the dialectic of appropriation and realization. The goal of labor refers to the material world; the realization of human goals connects the objective features of the natural thing with the needs of man. Both depend on the concrete conditions of the production means. The production conditions (Produktionsbedingung) in society create a field of opportunities where goals and intentions have to be connected. Moreover, the constitution of goals also depends on the state of technological and knowledge development:

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[39] This issue can be illustrated by the wedding situation presented in Section 1.4.1. As mentioned the question "Will you take this man to be your lawful wedded husband?" creates a social orderliness of time. The flow of the wicked situation saying yes or no is structured by that order, and the flow creates a material commitment in respect to the order constituted by the question (see also Brandom, 1994). This forces the subject to appropriate the situation, also in respect to the recognition of the existing order (although cognition, recognition and realization of order must not fall together).

The exemplary literary image of this is the case of Oedipus, where in the flow of story the fact that Oedipus killing a person that is his father waits for recognition.

> "Therefore, mankind always sets itself only such tasks as it can solve; since, looking at the matter more closely, we will always find that the task itself arises only when the material conditions necessary for its solution already exist or are at least in the process of formation" (Marx, 1988, p. 263).

Parenthesis: Marx's concept of appropriation should not be interpreted as an atomistic concept (as we found in De Sanctis and Poole's later work), but it meets the demand for a holistic concept, which is able to capture the evolutionary character of artifacts. In particular, Marx's considerations on appropriation reveal that the essentials of technical artifacts are not given by discrete, fixed, and timeless entities. Instead, technical artifacts as objects of our world are only given through the reflection determined from the background of a given world-disclosure or world-experience.

In becoming alienated from this given world-disclosure, subject and object are constituted by abstract reflection. Freed from the direct subordination to a purpose, the artifact can be identified as a contradictory embodiment. This re-defines the need for mutual subordination on a higher level of freedom, where the identity of the artifact mediates between subject's intent and object's constraint.

This has implications on different levels. On a theoretical level, the difference between the intentional and extensional artifact is not just wrong in a modern logical sense, but a contradiction in a Hegelian sense that is mediated and evolves through an anticipation of perfection. This means that there is a need for a place to mediate intention and extension. Chapter 4 will introduce the artifact present-at-hand as such a place serving as a boundary object between the intentional and the extensional object.

On a methodological level, the elements are constituted only through practical appropriation of the world, and only given in the reflection of the practical world-disclosure. Hence, research on technology appropriation should follow the logic of reconstruction and not the logic of subsumption: otherwise it can easily miss its research subject when studying the formation of technology as an intentional object. The practical implication is that the artifact as boundary object can only be presumed as an analytical given, while the concrete meaning has to be negotiated in the field.

These implications are taken into account by Business Ethnography as an Action Research conception for reflexive technology development and by Appropriation Infrastructure as a design conception supporting reflexive technology development.

3.2 Mediating sensuality and sociality

Needs (respectively power) can be perceived from their ontogenesis, as Röhr states: "the needs of humans – like all other goals of the process of labor – have been developed socially and historically" (Röhr, p. 47, translation by the author). Needs can also be perceived from the perspective of their phylogenesis as Márkus (1978) points out:

> "In the process of 'appropriation' (Aneignung) of humanized objects (which constitutes one of the main dimensions of socialization) the individual transforms into living-personal needs and the historically created social wants and abilities objectified in the elements of his milieu". (p.8)

In particular, ontogenesis and phylogenesis follow a similar structure. Marx adopts an even stronger connection by stating:

„[I]ndividual human life and species-life are not different things“ (Marx quoted from Fromm, 2005, p. 106).

An important aspect for characterizing the structure of formation processes – of both the individual and of the species as a whole – is that man does not only have a history, but also makes history by means of production. For this, the specific quality of the outcome of production, the product, is essential. It presents the accumulated objectification of human faculties. Through production, man creates the material and the intellectual world. As this creation becomes more elaborated, the connection to nature grows and becomes more differentiated: While human will cultivate nature, humans as species being cultivate themselves.

Röhr states that the relation between man and its products has a specific character:

> "Products as objective existence of the essential power of the human, as objectification of human competencies present the external being of man. They become what they are only by the virtue of man. Man is by himself by the virtue of his products, but at the same time they provide the mediated being of man. This presents a working duplication of the producer through labor in a subjective personal being and an objectified, external being of man. This presents therefore the essential appropriation, because it is the realized sociality of human beings" (p. 48 - translated by the author).

His product therefore does not directly belong to his own bodily being-in-the-world (Leiblichkeit), but he can freely face his product. The specific relationship between man and his product is characterized by the fact that artifacts being on the border of the own and the foreign body, being alienated and appropriated at the same time.[40]

This specific character of this relationship presents a constitutive element for the qualitative transition from expressive products to social products. Hence, the social quality of products mediating between production and consumption refers to, but cannot be reduced to expressive products mediating between man and nature, which itself is a specific feature of man as a species being.[41]

In order to clarify his argumentation, Marx draws a comparison with animals. Animals and humans share the property of being dependent on satisfying their needs through their own activity. However, animals live in a direct nexus between action and satisfaction. Activity focus on needs "directly *coincides with the process of active need-fulfillment*" (Márkus, 1978, p. 4). For animals, the objects of production coincide with the objects of direct con-

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[40] This view tackles the philosophical puzzle of how to mediate between the here-and-now and the once-and-here from the concept of embodiment, where the body is the place where appropriation occurs (see also the remark on Dourish's phenomenological view of appropriation on page 80). I pick up this phenomenological view on mediating self and nature in Section 4.2.

[41] The analysis of the constitution-theoretic relationship between expressive and social object is adopted to elaborate the conception of artifacts serving as boundary objects (see Chapter 4).

sumption, and to a very large degree they are fixed and essentially unchangeable, determined by their biological constitution (cf. Márkus, 1978, p. 4). Contrary to this, by virtue of his character as a free being, man detaches from this nexus. For him, labor becomes an activity not directed towards an immediate, but towards a mediated satisfaction of a need. In this sense, production and consumption are separated into two different spheres. The mediation between the two is given through the product. Moreover, the product is a constitutive element in freeing production from consumption.

This mediating function can be described from a temporal perspective as a delay in satisfaction. However, in order to get a more profound understanding of appropriation, it will be useful to derive this mediating function of products from human universal potentiality.

Although production and consumption are connected by the product, production obtains its own quality which cannot be reduced anymore to a direct need satisfaction. More precisely the need satisfied by the product through consumption does not coincident anymore with the need of the producer. Accordingly, consumption acquires a quality of its own as well. As a result, production and consumption are in a relationship of mutual mediation , in which the concept of the product is disengaged from the direct satisfaction of a specific existing need. However, it is not disengaged from the general concept of needs (although it is possible that the produced object will never satisfy a need, or that a specific need will emerge by and through the emerging product).

Treating the relationship from the production side, one stresses the aspect that production creates the object of consumption and its use modalities. In this respect, the consumer of the object is affected by production. From the consumption side, the product is a purposeful object only insofar as it is practically completed, that means, if it is suitable for the desired consumption purpose. Production is completed only if the product succeeds in meeting the needs of consumption, which means that the former is mediated by consumption. In this sense, the product includes a mutual mediation of production and consumption, although consumption cannot be deviated from production any longer (and vice versa).

As a consequence of this, production and consumption emancipate from each other. At the end of this emancipation process, consumption cannot be seen as a predestined conclusion of production anymore, while the practical use value of products becomes uncertain. In the limit case of innovation development, consumption is only abstractly given. It can only be retrospectively asserted if and for which purposes the object can serve as a product: without being used for driving, a stone does not have the practical value of being a wheel, while those who invent the wheel is at in risk that there is no need for it.

Parenthesis: To step out of the direct nexus between action and satisfaction presents also a necessary condition for the formation of interests. In Section 1.4.2, this topic was deduced from the role of the generalized other as a condition for mediating meaning construction. This line of thought can now be supplemented by a long overdue theoretical argument. Overall the argument is that the mediation of needs only occurs when the needs not directly coincide with the process of active need-fulfillment. However, in the case where needs must be mediated, they also must be translated. This constitutes a space where the quality of needs is replaced by a quantitative notion of needs. In communication this is the sphere of interest, while in the materialization, this is the sphere of money.

Fischer (2002) alerts us that this is also a relevant issue for Participatory Design and End User Development. In his article, there is a short paragraph on the division of labor where he compares consumer and designer roles with regard to their interests. In this paragraph, he perceives a mismatch in roles when consumers only want to be a designer in personally relevant activities, and designers only want to be a consumer in personally irrelevant activities. This remark can be interpreted from the viewpoint of Activity Theory as addressing "the contradictions within and between the interacting activity systems of […] the manufacturer […and …] the user organization" (Hasu and Engeström, 2000).

From this perspective, the notion of a Symmetry of Ignorance (Fischer, 2002) is defined as a contradiction between the interests of the stakeholders. The needs of users and producers regarding the product do not coincide. They have different interest systems, as the interest of the user in the exchange value of the product is mediated by its use value, while the interest of the producer in the use value is mediated the exchange value.

In his `Critique of Political Economy´, Marx describes the relationship between needs and products, and consumption and production as follows:

> „Production not only provides the material to satisfy a need, but it also provides the need for the material. When consumption emerges from its original primitive crudeness and immediacy – and its remaining in that state would be due to the fact that production was still primitively crude – then it is itself as a desire brought about by the object. The need felt for the object is induced by the perception of the object. An *object d'art* creates a public that has artistic taste and is able to enjoy beauty – and the same can be said of any other product. Production accordingly produces not only an object for the subject, but also a subject for the object.
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> Hence production produces consumption: 1) by providing the material of consumption; 2) by determining the mode of consumption; 3) by creating in the consumer a need for the objects which it first presents as products. It therefore produces the object of consumption, the mode of consumption and the urge to consume. Similarly, consumption produces the *predisposition* of the producer by positing him as a purposive requirement" (Marx 1972, p. 624).

Furthermore, products are objectifications of man's essential powers (Wesenskräfte), yet also expressions of the social relationships which have been objectified in the product. In the product, the social-historical conditions between humans are mediated. In this context, Márkus (1978, p. 23) speaks of a transition from man as a *universal nature being* to man as

a *universal social being*. This historical moment is exhibited by the fact that individuals not only work together, but start to work for one another. This moment is expressed by the products:

> "As production develops, it acquires a social character not only in its abstract form […], but also in its concrete content, in the sense that the individuals begin to produce *for* each other, their labor becomes in reality only a component part of the total integral production and reproduction process of the whole society. Personal collaboration, directly cooperative work in small, independent local communities is replaced by a *division and combination of labor* the scope of which progressively comprehends the whole world. […] In this way the life of every and each individual becomes dependent on the activities of a growing circle of other individuals with whom he no more stands in personal contact and communication, but at the same time each human being thereby acquires – at least *in principio* – the possibility to make use not only of human experiences, of objective and subjective wealth accumulated in his particular community, but of those accumulated by the whole mankind" (Márkus, 1978, pp. 23).

Parenthesis: So far, we can state that for Marx the self-constructing nature of humanity has a synchronic dimension in which practice is shaped by the existing material and social conditions and a diachronic dimension in which practice is grounded in history and history is made by practice. Both dimensions shape object and subject as historical beings.
As a constitution-theoretical assumption, man is characterized as a species being which is autonomous from nature through nature. This presents Marx's anthropological background, were he describes the dialectics of 'appropriation' (Aneignung) and 'realization' (Verwirklichung), the dialectics of 'power' (Kraft) and 'needs' (Bedürfnisse), and the dialectics of 'production' (Produktion) and consumption (Konsumption). All these elements posit a socio-historical character and all of them are parts of a unity, which will be mutually mediated by products as objectifications (Vergegenständlichung) of labor.
Moreover, Marx consideration of the mediation role of products allows to generalize Pipek's notion of use discourse environments. The discourse about usages among a user community can be sublated in the notion of products discourses among a product community. The product community is constituted and mediated by the product in its ongoing cycle of production. The Appropriation Infrastructure should therefore support the appropriation among a product community, where a use discourse environment presents a special case.

Further, Marx studies the implications of different forms of societies in history. He differentiates several economic epochs by applying general analytical factors such as production, distribution, work and means of production and how they are organized in society:

> "The specific manner in which this union [of the different factors] is accomplished distinguishes the different economic epochs of the structure of society from one another" (Marx, 1956).

For the analysis of societies, the concept of alienation plays a crucial role, whereas the concept can be interpreted as empirical or analytical category for studying bourgeois society. In the first case, one might say that alienation *is* a specific quality *of* the bourgeois so-

ciety, while in the latter case one might say alienation *has* a specific quality *in* this very society through the dominant means of production.

In my thesis, I interpret alienation mainly as an analytical category with respect to the constitution of man as a universal being.

As pointed out by Márkus (1978), "even in the period when the tendencies of alienation dominate, it is the individual himself who makes his own life – though perhaps within very narrow confines – out of this material" (p. 23). This critical remark makes aware that one can easily misinterpret alienation as a binary operation, through which man lost his essential power in bourgeois society, if it is just seen as an empirical category of the bourgeois society.

Besides such a tendency to misinterpret the concept of alienation, also from the perspective of an expressive evolutionary anthropology, it is suggested to interpret alienation as an analytical category. In particular, from the constitution-theoretical interpretation of Marx and Hegel, alienation presents a constitutive moment of the concept of appropriation of man as a free being. The argument for this perception can be stated as follows: in the nexus of immediate action, man and nature are not separated. But from a constitution-theoretical perspective man becomes a free species only by virtue of this separation, which also represents an alienation of man from nature.

From an analytical point of view, the concept self-expression is only thinkable through the concept of alienation. Hence the authentic self-expression in nature as sublation of self and nature does not mean that such a stage can be reached by going back to a previous stage in history where alienation does not exist. In the authentic self-expression alienation from and appropriation of nature is instead sublated in being concurrently present, but transcended in the free recognition of the other. The attribute 'authentic' means, for both elements to be present is a necessary, irreducible moment. One corollary is that the concept of authentic self-expression in nature does not refer to the material construction of an artifact, but to a performative factuality of life practices which can be theoretically described in dialectic terms only.[42]

In his analysis of bourgeois society, Marx distinguishes four different modes of alienation which take different perspectives into account:

[42] At this point there are several linkages to the aesthetic-theoretical consideration presented by Pilz (2007), but this should not be elaborated here. The major issue of this consideration is to suggest 'alienation' as an analytical, and not so much as an empirical category.

"First, from the product, which as soon as it is created is taken away from its producer. Second, in productive activity (work) which is experienced as a torment. Third, from species-being, for humans produce blindly and not in accordance with their truly human powers. Finally, from other human beings, where the relation of exchange replaces the satisfaction of mutual need" (Wolff, 2003).

3.3 Appropriation and alienation as analytic categories

Applying alienation as an analytical concept to study historical forms of society identifies specific problems of fragmentation of man's essential powers with respect to the dominant production means. Following Marx, the different forms of society can be characterized by the actual distribution of the production elements (Verteilung der Produktionselemente). They organize the distribution of possession of the means of production (Eigentumsverhältnisse der Produktionsmittel) as well as the division of labor (Verhältnisse der Arbeitsteilung).

The analysis of alienation in the actual society reveals that through the current division of labor, alienation is not only an issue for the human in her role as a waged worker, but also in his role as a consumer of mass production. It was mainly Critical Theory who emphasized that alienation of man also affects the consumption side of labor. In their analysis of cultural products, Horkheimer and Adorno (1997, first German edition 1947) coined the term "culture industry" (Kulturindustrie). With this term the authors wish to stress that the tendency of commodification of cultural goods follows the logic of the capitalistic form of production. Culture industry is at the same time a product of the "coercive nature of an alienated society" (Horkheimer and Adorno, 1997, p. 121) as well as a condition for their reproduction, with the result that "the circle of manipulation and retroactive need in which the unity of the system grows ever stronger" (Horkheimer and Adorno, 1997, p. 121). First and foremost, Adorno and Horkheimer contradict the statement that the rise of mass-produced culture presents only a technological change in the reproduction of cultural goods, and is only a necessary response to satisfy existing and immutable needs of the masses:

"Interested parties explain the culture industry in technological terms. It is alleged that because millions participate in it, certain reproduction processes are necessary that inevitably require identical needs in innumerable places to be satisfied with identical goods [… and the] standards were based in the first place on consumers' needs" (Horkheimer and Adorno, 1997, p. 121).[43]

[43] In rejecting any presumed primacy of needs without reflecting the socio-historical conditions which create these needs, Adorno and Horkheimer are in line with a Marxian perspective. See Márkus (1978) also, who

Marx shows that the sphere of consumption has a quality of its own within the actual distribution of production elements. Marx develops this perspective on consumption by an argument that indirectly criticizes a specific reception of Hegel (cf. Marx, 1973, pp. 93). Production and consumption, he argues, are only identical for an individual subject. Only in such a case can they be perceived as two parts of a single act. However, when studying society in concrete terms (and not in an abstract way as Idealists do) it becomes obvious that this is not a single object, but a tangled web:

> "In society, however, the producer's relation to the product, once the latter is finished, is an external one, and its return to the subject depends on his relations to other individuals" (Marx, 1973, p. 94).

Therefore, production and consumption are not identical and hence, consumption has its own quality. In particular, consumption also includes a moment of production regarding the meaningfulness of the object, which is mediated by the situation being itself embedded in a socio-material context. This argument shares many aspects with the idea of production-in-use, which was elaborated in Cultural Studies (cf. Storey, 2006).

Parenthesis: This brief survey shows that the Marxian categories can be interpreted as empirical facts referring to the bourgeois society as well as an analytical lens to study society in general. My thesis rests on an analytic view seeing labor and products as results and means of appropriating of nature by realization in nature (and vice versa). As analytic concepts they have a similar theoretical function as the duality concept with Giddens. In both cases, labor as situated development presents a totality mediating agency and structure as mutually constitutive elements.

In particular, I borrow the terminology of Giddens to characterize appropriation and realization as two moments that mediate between agency (embodied by man) and structure (embodied in nature). They are mutually constitutive because without structure nothing exists to realize an intention; however without intention the term realization does not make any sense. In that view, appropriation refers to assigning meaning to structure, while realization refers to expressing meaning in structure. In this the concept of appropriation is close to Giddens (1995, 1984) constitution-theoretical specification of agency as the 'freedom to act otherwise', which can be interpreted to the dialectic of utopian thinking and utopian praxis (see page 25).

We can now further elaborate this analytic view on appropriation in exploring the specific nature of the mediation of agency and structure. In this view, appropriation is given by a triadic relationship between the concepts of realization (Verwirklichung), cognition (Kenntnis), and recognition (Anerkennung): Realization needs cognition with regard to the intention as well as the laws of nature given by the object. In addition, a realization creates a factuality of the own life praxis which ongoingly has to be appropriated by the subject.

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writes: "One of the frequently occurring misunderstandings in the Marx-literature concerns just the question of the relationship of work and wants [resp. need]. […] The departure from needs and consumption constitutes for Marx a characteristic sign of reactionary economic thought. […] And indeed, by accepting needs in the role of the primordial, ahistoric and fixed *data* of social life, one is led to a relativistic denial of any kind of historic *development"* (Márkus, 1978, p. 67).

This factually forces the recognition of both, intention and laws of nature expressed in the realization.

I interpret the basic relation between cognition, recognition and realization as a constitution-theoretical statement, which describes the structurally given autonomy of Lebenspraxis or creativity of action (if is interpreted in the sense of Joas and not reduced to a voluntaristic concept). In its subject matter, it describes the moment of freedom when man steps out of the nexus of immediate action (see Section 3.2). Taking this into account, appropriation can be characterized as the competence to recognize a foreign object's own meaning, and realization as the competence to change a foreign object's own meaning.

The essential feature of appropriation is potentiality and not actuality. This doesn't mean that appropriation cannot be empirically studied. The seminal point is that we cannot reduce appropriation to the result of situated action, but we must put this into relation to the potentiality embodied in the situation.

A (counter-intuitive) consequence of the principle of embodiment is that potentiality as part of situated actions posits an objective reality. The methodological consequence for empirical research is that one should describe action in its factuality, but also to reconstruct it in its potentiality. In particular, the reality status of potentiality is a distinguishing feature between positivistic and critical research methodologies: Factuality can be measured, potentiality must be hermeneutically deduced.

Once one accepts that potentiality has an objective reality, it becomes easy to grasp why the existence of unintended use is just an indicator for appropriation, but not the thing itself: For example, appropriation is also given by competency to use an artifact not in an unintended way. However, in such a case an external observer is not forced to introduce the concept of appropriation in order to explain the observation. Instead it presents the intended use of a degenerated (in a Peircean sense) realization of the concept of appropriation.

From an empirical observation of the actual reality one cannot distinguish if an observable behavior is intended, accidental or for example just a simulation of human behavior by a computer program. Therefore we cannot give any valid empirical criteria to make such a distinction; instead, empirical analysis has to subsist on the counter-factual assumption that e.g. an artifact or an artifact usage is the expression of a life form given by the dialectic of appropriation and realization.

The considerations about the constitution-theoretical status of appropriation also hold for the concept of alienation. Also in this case, Marx leaves room for both interpretations, taking alienation as an empirical fact referring to the bourgeois society as well as an analytical lens to study society in general. Independently of which interpretation we prefer, alienation presents in both cases a category derived from the dialectic unity of labor and products given by the idea of objectification of labor.

The objectification of labor is a counter-factual concept which makes an anticipation of perfection where the relation between idea and its realization is sublated in well-done expression. Stating alienation as an empirical fact implies the objectification of labor (or an isomorphic concept) as an analytical category in order to explain what the empirical fact means.

Using the dialectic unity of objectification as an analytical lens to study actual society reveals that the separation of production and consumption leads to specific forms of fragmentation, which needs other mediation strategies than, for example, in archaic societies. A well-known mediation-strategy in actual society is marketing and marketing research to bridge distributed production and consumption. Other approaches currently discussed, such as User Innovation, reflect upon the question how production processes which happen outside the producer's context can be mediated and reconnected to production more systematically.

We can apply this analytic lens on EUD research. Concepts like tailorability (Kyng, 1991) and use discourse environments (Pipek, 2005a) can be interpreted as two different strategies to overcome fragmentation in the use context by supporting situated development.

Tailorability as a part of Meta-Design provides (hopefully) appropriate tools that allow the owners of the problems to communicate with the systems at a level that is situated within their world (cf. Fischer, 1994). This mediation strategy is complemented by the SER model (Fischer, 1998) which argues for new mediation forms to bridge fragmented production and consumption. Meta-Design can therefore be characterized as an approach that integrates mediation strategies on different levels of fragmented development. However, one of the drawbacks of Meta-Design as a conceptual framework is that it does not clarify the distinction between analytical constructs and empirical results.

There are two pitfalls resulting from the missing explication. On the one side, there is the danger to reify an analytical construct, e.g. projecting own belief what end users can do and need, instead of studying these issues in praxis. On the other side, there is the danger to eternalize historically contingent situations by confusing actual observation and theoretical necessity, e.g. taking a particular division of labor for granted without explicating the diverse causes for such a situation. In the case of Meta-Design, such a problem occurs with the role of the meta-designer. It is not clear whether this is an analytic construct to uncover actual phenomena in the age of Web 2.0, or if it describes a role that needs specific competency and power.

As a result, Meta-Design suffers from a latent tendency towards a pro-producer (more precisely a pro-'meta-designer') bias, failing to take into account how roles will be constructed and assigned. On this point, Pipek's (2005b) consideration on shared infrastructure is more informative in reflecting on the issue of becoming a user and a designer, respectively, and how the use of shared infrastructure (implicitly) constitutes various consumer-to-consumer, consumer-to-producer and producer-to-producer etc. relationships. In particular, in the cases of highly dynamical configurations of humans and non-humans (as I have seen for example in my studies on Eclipse) the less demanding conception of Pipek is useful for studying the formation of an evolving field as constituted by infrastructure, for instance (cf. Pipek and Syrjänen, 2006, fig. 1).

Another issue is the notion in Meta-Design of the *owner of the problem*, where the concept posits a common sense, but its meaning is not explicated, especially if the ownership is based on self-attribution or is an attribution made by the external observer. Additionally, from an evolutionary constructivist view the question arises whether the attribution is based on retrospective reflection, resulting from the formation of problems in the appropriation of wicked situations.

I interpret the term as a normative stance which is confronted with the dilemma that there are cases where the designer must first solve a wicked situation to frame the problem, and hence to frame who is the owner. At this point, Meta-Design is fading out of this topic as it presents a structural dilemma for emancipatory design. In particular, a static view on problems and ownership also neglects the formation of needs, and the role the designed world plays in this process. Ignoring this fact was one of the criticisms Adorno leveled at the culture industry. The paradigmatic case of wicked situations demonstrates that designers cannot prevent to construct reality in substitution to a real or anticipated other (typically the user or customer). However, this does not mean that the constructed world can be appropriated differently. In particular, interpreting wicked situations in substitution creates the possibility of misinterpretation, therefore designers should reflect on this issue in a professional manner. This make it necessary that one is aware of the responsibility that solving wicked situations means to interpret the world for someone else. In a case study Meurer (2008)

has demonstrated that this is also an topic in commercial product development. In consequence the competence to solve wicked situations in substitution also needs the competence for a critical self-reflection, and hence both should be part of a professionalized (meta-) design (cf. Stevens et al., 2009b). Against this backdrop, I have outlined a revisited model of the Wizard of Oz method (cf. Mueller et al., 2007). This new understanding of the common method in HCI uses the simulation of the anticipated system by a Wizard of Oz also in its potential for designers to appropriate wicked situations in substitution. In addition, it enhances it by the method of discursive reflection so as to support a systematic critique of the interpretations made in the framing of the problem

3.4 Summary

In this section we saw that artifacts can be understood as both result and condition of socio-historical formation processes. Moreover, these formation processes are accumulated in and mediated by the produced artifact. From the analytic lens of the objectification of labor the product and its usage was perceived as expression of subjects. However, the two aspects of objectification – appropriation and realization – form a single entity as idea while being separated in the empirical world and must be mediated. Hence, the dialectic of appropriation and realization presents the fundamental form of fragmentation given by virtue of the human as a free being, even though the specific fragmentation and the appropriate means for mediation depend on the concrete production conditions.

Regarding research on EUD, the idea of products as objectification of labor has two aspects. Firstly, the idea provides an analytical framework for studying the specific fragmentation and the corresponding conception of development, aiming to support the mediation between the fragmented elements. Secondly, as a part of evolutionary anthropology, the concept of objectification provides a regulative idea perceiving the objectification of labor as means that allow humans to attain their full potential as a universal being. This idea is also related to the socio-political utopia of emancipatory practice. Here, emancipatory practice can be understood as a democratized, collectivistic variant of the Romantic idea of an authentic self-expression of man.

Supporting non-professional developers in their modifications to the material and symbolic construction of software artifacts, which presents a core element of EUD research (Lieberman et al., 2006), can be interpreted as a means of supporting emancipatory practices on the individual level, which nevertheless have to be sublated by an emancipatory

practice on the social level.[44] Hence, the evolutionary and expressive constitution-theoretic consideration of the formation of humans and their artifacts, and especially the concept of products as objectification of labor provides an analytical fundament as well as a regulative, normative idea for thinking about EUD and related concepts such as Fischer's conceptual framework of Meta-design or Pipek's conception of appropriation work.

In particular, Marx's definition of a product as a constitutional element for mediation, motivated by the idea of the unity of objectification of labor, provides an appropriate starting point to study their fragmentation, thereby revealing options for their (partial) integration.

In the next section, the aspect of software artifacts serving as a boundary object is elaborated from this perspective. The elaboration of the boundary object concepts also adopts Marx's notion that sensuality and sociality are connected in the objectification of labor, where the rationality expressed in a particular expression is endowed with a claim on generality and only criticizable from such a claim.

[44] From this perspective, it is quite obvious that End User Development and Participatory Design share a common socio-political ambition, and therefore it is quite natural that both can be grounded in evolutionary anthropology. This raises the question of the difference between EUD and PD. One can try to separate EUD and PD so that EUD addresses the technical issues of designing more flexible software systems, while PD focuses on a more user-centered requirements analysis. However, such a division of labor risks losing sight of the overall goal of emancipatory practice, which could lead to a technocratic reduction of PD and EUD.

4 Software artifacts as boundary objects

In previous chapters, I have explicated the semantic field of Marx's appropriation concept. Appropriation refers mainly to the socialization of artifacts forming the dialectic unity of material and symbolic co-construction. It refers to the historical development of ideas, which cannot be separated from the moment of its realization, while the realization cannot be separated from the development of ideas.

The anthropological foundation of appropriation also applies to technical artifacts as commodities. They mediate between consumption and production among a product community. This chapter supplements this analytical perspective on appropriation with a phenomenological perspective on situated development, where the artifact present-at-hand serves as boundary object in and for the appropriation of wicked use situations.

The concept of boundary objects was originally introduced by Star and Griesemer (1989) as an analytical concept to explain the mediation of knowledge between actors that belong to different social worlds. I reinterpret the concept in terms of a Dialectic Expressivism as provided by Marx, utilizing the concept for grounding my empirical observations in theoretical terms. The elaboration of the revisited model of boundary objects was therefore shaped on two sides.

On one side, my work was shaped by the practical problem of evaluating the results of my design study, where I tried out some features of the Appropriation Infrastructure in the wild (see Chapter 6). Forced by my empirical data I searched for a grounded theory that can uncover the structure of the challenges users have to cope with in making wicked situations accountable. Reconstructing the genesis of design participation from a user's perspective leads to the wicked situation as a constitutive act regarding the emergence of situated boundary objects. The paradigmatic case for such wicked situations is a crisis in use creating an inhibition of action, but also initiating a reflexive development to solve the crisis.

The aim of the revised boundary object model was to explicate the mediation instances that become relevant regarding the user perspective in appropriation such wicked situations. The model therefore reconstructs the sequence of qualitative transitions in changing a wicked situation from a genuine doubt to a controlled one. In particular, the model should reconstruct the transition from the embodied interaction to the communicative collaboration, where a wicked situation can be made into a social object. Here the analysis demonstrates that the artifact serves as boundary object between designer and user as suggested by

Fischer (1999), but the examination also shows that this is only one option among others in the evolution of a wicked situation.

On the other side, my work on a revised boundary object model was influenced by existing theoretical work on the mediation quality of products. In particular, my work is shaped by the emphatic view of Marx on appropriation, as it provides an appropriate understanding of the constitutive structure of the dialectic artifact. The model is further influenced by a remark of Fischer's (2001) that software artifacts can serve as boundary objects in the interaction between users and (computational) environments (see Section 1.4.3). In addition, the suggested dialectic re-interpretation has a strong affinity to Engeström's concept of boundary objects. Both are theoretically grounded in the notion of products as mediators in the ongoing cycle of commodification. Moreover I share with Engeström the dialectic view on the constitutive structure of the artifacts, arguing that the functional quality being a mean to an end is no essential feature of the material makeup of artifacts, but relative to an activity (see also Engeström and Escalante, 1996).

Reconstructing the genesis of making a wicked situation accountable, I have identified three stages of mediation in the evolution of a situated boundary objects are related to the generalizability, communicability and experiencability as constitutive conditions making innovation development in society possible (see Section 1.3).

Looking at the end of its genesis, the artifact as boundary object has become a political quality (see Section 4.4), where the reflection about the artifact construction is linked with reflection about a corresponding socialized practice. Asking for constitutive elements of the political quality shows that their emerging qualities are derived from the social quality of the boundary object (see Section 4.3).

The social quality of the boundary object characterizes the reciprocal feature that the social artifact can be identified from different perspectives, and different perspectives can be identified from the social artifacts. Asking for constitutive elements of the social quality shows that their emerging qualities are derived from the expressive quality of the boundary object (see Section 4.2). In order to identify different meanings, one has to abstract from the concrete meaning without losing the concrete object, which is a far from trivial observation. This point becomes more obvious from a corollary perspective on boundary objects that is grounded in a dialectic understanding of artifacts. This perspective highlights the fact that the connections between material and meaningful objects are perspective-dependent as well as entirely contingent in detail. Analyzing this contingency in its logical structure, one will see that a condition for the possibility for contingency is identity. This means that in the

case of artifacts, there must exist a connection between construction in meaning and material. Moreover, this mode of connectedness must preserve a meaning that transcends the immediate situation. Here, the embodied artifact in use mediates between an immediate situation and a material-historic context transcendent of the situation. The quality of freeing the relation between concrete object and concrete meaning without losing the relation refers to Romantic idea of self-expression. The social boundary object must participate on that quality level, although it cannot be reduced to this quality. In this sense, the social quality operates on the expressive quality.

The expressive quality emerges in the initial stage of reflection where the artifact becomes present-at-hand, freed of the immediate connection to be a means to an end. This initial stage can therefore be specified as the expressive quality of boundary objects (see Section 4.2).

The expressive quality of boundary objects is maybe the most difficult one to understand and is related to some unsolved problems in philosophy, of how emergence can be thought without contradictions (cf. Pape, 1994). However, the debate in IS on Structuration Theory has demonstrated that we cannot completely neglect such questions, if we want to get an adequate understanding of our research topic, namely the use and development of technology in practice. What is true in general, is unfortunately also true regarding my research topic of supporting users to articulate situated developments. In particular, in order to understand the underlying theoretic structure of the situatedness of appropriation, it was necessary to enlarge the boundary object conception by an evolutionary dimension that takes the expressiveness of situations into account.

Roughly spoken, my strategy to tackle the topic is to interpret the artifact present-at-hand as a situated, evolutionary boundary object. As outlined in Section 1.4.3 I treat boundary objects in their formal structure as a kind of Thirdness in a Peircean sense (cf. Peirce, 1992b, first print 1877) and adopt his ideas of continuity and spontaneous emergence. To apply the logical view on mediation on the concrete case to mediate the distributed evolution of artifacts, I also adopt Mead's (2002) conception of a social present, where development is given by emergent events.

From the perspective developed below, Star's original conception presents a special case that relies on a spatial perspective mediating knowledge construction across social worlds (see Section 4.1). This thesis will re-conceptualize the original ideas in order to capture the situated, evolutionary quality as well. This re-conceptualization is grounded in a formal defi-

nition explicating the features that are needed to serve as a boundary object in an open, evolutionary environment:

Characterization of an evolutionary concept of boundary objects:

1. Boundary objects as (trans-)situated objects: A boundary object is plastic enough to mediate between different times and spaces.

2. Duality of boundary objects: A boundary object has, is, and is part of a social structure that is both medium and outcome of social action.

3. Boundary objects as creatures of crisis: A boundary object has, is, and is part of an evolutionary structure that is both medium and outcome of emergence.

4. Sociality of boundary objects: The plasticity of boundary objects is given through the specific mediation quality of carrying more than one perspective at once.

5. Boundary objects as continuum: The temporal-spatial evolution of the boundary object is given in a continuous flow of action. In particular, an (infinitesimal) cut as single moment in the evolution of a boundary object presents simultaneously a static snapshot, and the ongoing flow of its continuous development. In particular, in its formal characteristics, a cut has in itself the form of a boundary object. In other words, the evolutionary structure of boundary objects is self-similar.

The first point regards the key element of Star's definition of boundary object into account, but transformed it from a situated point of view which emphasizes the need for mediation between social space and social time.[45] The second point regards the key element of the debate on structuration and appropriation in IS, namely the insight of the recursive duality of social structure being medium and outcome of social action. The third point regards the key element of the design discourse into account, namely that innovation development in wicked situations has to deal with the appropriation of emerging structure. The fourth and the fifth points are not theoretical demands, but rather pragmatist interpretations of the other three requirements. The fourth interprets the three demands from Mead's understanding of sociality, while the fifth point further elaborates the interpretation in the light of Peirce's continuum concept.

The characterization can be interpreted as follows: As a situated boundary object in the here-and-now represents a cut in the sequentially ordered flow of its evolution, the resulting point is not atomic, but again a sequentially ordered continuum with blurred borders. The term cut is adopted from Dedekind's notion of Schnitt (or *Dedekind cuts*) as a conceptual

[45] Star mainly focuses on the problem of mediating knowledge construction across social worlds. However, Star (1990) remarks that the conception of boundary objects is closely related to the question of how in open evolutionary systems, identity is maintained over time. Unfortunately, she does not examine the evolutionary structure in more detail.

means or method of cutting parts or of making conceptually discrete what is in fact a continuum. This picture of a cut characterized by its specific mediation quality relies on Peirce's continuum concept (cf. Zink, 2004, Zalamea, 2003) and his notion of a sign being a cut during semiosis, as well as remaining always connected to the continuous semiotic process. This view is also expressed in Peirce's remarks on the consciousness of the present time, where he argues that the conception of a single discrete instant falls into grave difficulties. The flow of time is speciously present, which is in fact strictly infinitesimal (cf. Bell, 2005, p. 211). The structural feature through which past and future are connected in the present is also the cornerstone of Mead's philosophy of the specious present and his notion of the mediating quality of emergent events. This in turn is influenced by Hegel's idea of sublation as a moment of progressive development. Moreover, Mead becomes aware that this structural feature of the present provides a theoretical concept of sociability. Bringing Hegel and Peirce together via Mead, one can say that the specious present can become the occasion of experience, where the emergent event is a manifold in which past and the futures as possibilities can be prescinded in a Peircean sense as connected.
The elaboration of the situated boundary object model can be interpreted as applying the structural considerations of this cross-section in a continuous flow of artifacts. In this sense, the artifact present-at-hand is a cut in the flow of its continuous development. Hence, the artifact is not a discrete instance, but a boundary object that mediates between the different moments of its construction.

In the following, the different stages in the life of an artifact serving as boundary object will be presented. One consequence of theoretical understanding is that the phylogenesis as well as the ontogenesis of the boundary object in general posit an emergent quality which referring to the moment of an open future. From a methodological point of view, this means that empirical analysis has to start with the end of the object's genesis in order to determine in a reconstruction-logical manner the constitutive elements and the inherent rationality and necessity of the evolution.

4.1 Origins of the concept of boundary objects

The term boundary object was originally introduced by Star and Griesemer (1989). In their scientific studies, they denied the existence of an *a priori* reality constituting an objective authority for deciding which knowledge is true or correct. Instead, truth is seen as a relational concept inherently bounded to social practice. This leads to the idea of local truth,

where “each local truth is partial and flawed; no *a priori* specification can encompass any global truth” (Star, 1996, p. 303 quoted from Strübing 2005, p. 254).

Such concept of local truth – where knowledge construction is bound to the perspective of a particular practice – leads to the question how scientific knowledge is constructed across different localities, scientific disciplines and knowledge cultures. This underlies the theoretical problem for which Star and Griesemer suggest the concept of boundary objects. Boundary objects are located in different social worlds at the same time, and play substantial roles in mediating, translating and boundary crossing processes.

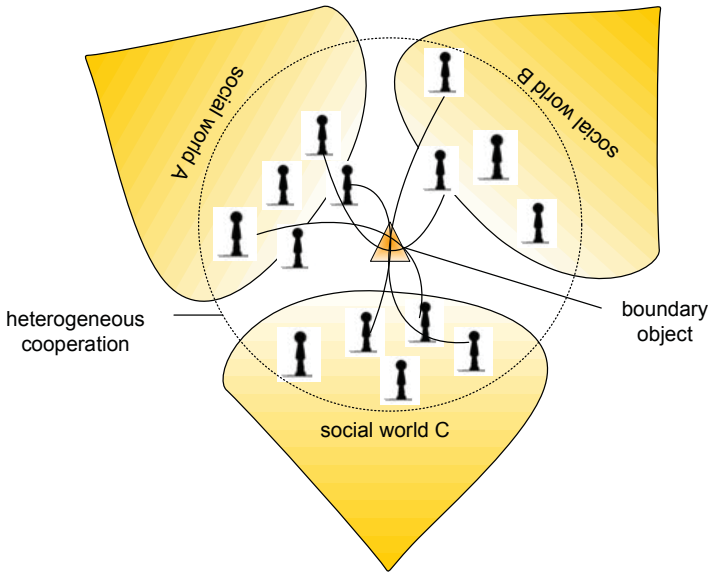

Figure 6 Visualization of the boundary object appearing in heterogeneous cooperation across different social worlds (Illustration after Strübing, 2005).

Following Griesemer and Star (1989, p. 293), boundary objects are perceived as an analytical concept, and characterized by their functional role of mediating knowledge construction processes between and across social worlds (cf. Figure 6). Therefore, they must fulfill some requirements, which, in turn, can be used to define such objects:

> “Boundary objects are objects that are both plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites” (Star and Griesemer, 1989, p. 293).

Star and Griesemer (1989) use the analytical concept of boundary objects to study mechanisms of knowledge construction, examining an example of amateurs and professionals establishing a natural history museum on the US west-coast in the first half of the 20th century. The authors identify four different types of cooperation processes and translation tasks in the system of boundary objects, which they call ‘repositories’, ‘ideal types’, ‘coincident

boundaries' and 'standardized forms'. Repositories are ordered collections of objects which are indexed in a standardized way, e.g. in the case study, libraries or museums. Ideal types are abstractions from different domains and may be rather vague; in the case study, these are study diagrams, maps or atlases which do not accurately describe the details of any local context, but are good enough to serve for communication among all parties. Objects with coincident boundaries, such as the terrain of the state of California, are common objects having the same (geographical) boundaries, but different internal contents. Standardized forms are objects allowing different communities to communicate in a common way; in the case study, a standardized form to be filled out by amateur collectors realize a boundary object as a common structure between amateurs and professionals.

Star and Griesemer (1989) neither argue that their list of the different types of boundary objects is exhaustive, nor that they have identified types that can be found in this form in any other case. To prevent the concept's reification, Strübing (2005, p. 255) points out that one has to strictly separate the analytical conception of boundary objects from a heuristic identification with specific material attributes.[46]

In the meantime, several researchers in different research areas have adopted the concept of boundary objects for their purpose. Wenger (1998), for example, adopted this concept in his research on Communities of Practice (CoP). He introduces the concept of boundary practice to describe the overlapping and criss-crossing practices of CoPs. Another prominent example in ICT oriented Organization Science is Carlile's (2002) work, which applies the concept of boundary objects to elaborate a theoretical framework for studying product development processes from an organizational knowledge perspective.

In EUD-related research, the concept is for example used to analyze the role of prototypes in user-designer cooperation, where

> "the material form of prototypes and models, acting as boundary objects (Star, 1990) [posing the same material boundaries but different internal contents], aligns participants in synchronous design-games of designers and users (Participatory Design), infrastructure in the process of infrastructuring (Star and Ruhleder, 1997) binding design-games of designers and future designers/users together (meta-design)" (Ehn, 2008).

Fischer (2001) also adopts the concept. He emphasizes the brokering role of boundary objects in collaboration across CoPs. Especially in software development projects, where

[46] The suggested situated boundary object model is in line with Strübing's argument that boundary objects are not empirical objects that can be identified by specific material attributes. However, the formal definition of boundary objects on page 100 goes beyond Strübing's distinction, as depending on the research angle, it can be interpreted as an analytical as well as an ontological model.

representatives of different CoPs are brought together for a certain purpose, forming a Community of Interest (CoI), the brokering role of boundary objects becomes vital. Fischer (2001, p. 70) argues that in CoIs, boundary objects support learning processes and social creativity.

In this article, Fischer indirectly mentions the constitutional role of artifacts connecting different CoPs, thus forming latent CoIs in which the artifact serves as boundary object:

> "In everyday life we constantly deal with artifacts that connect us in various ways to CoPs to which we do not belong. Boundary objects serve multiple constituencies in situations where each constituency has only partial knowledge (based on the symmetry of ignorance) and partial control over the interpretation of the object" (Fischer, 2001, p. 72).

Following Fischer, artifacts can serve as boundary objects for two major purposes:

> "(1) they can serve as objects to support the interaction and collaboration between different communities of practice, and (2) they can serve the interaction between users and (computational) environments. [sic]" (Arias and Fischer, 2000, p. 569, Fischer, 2001, p. 73).[47]

Unfortunately, Fischer does not elaborate on the role of artifacts for constituting a CoI further, despite interesting connections between the perception of artifacts as boundary objects and Marx's thoughts on the mediating character of products. Such a connection between both conceptions is made by Engeström, who attempts to integrate the concept of boundary objects into Activity Theory as a tool for "analyzing and transforming networks of culturally heterogeneous activities through dialogue and debate" (Engeström and Miettinen, 1999, p. 7). Engeström develops the idea of products acting as a boundary objects in his considerations of co-configuration (cf. Engeström, 2008, Engeström, 2007, Virkkunen and Engeström, 2001). Co-configuration presents a shift in the understanding of production processes, with the central idea that "co-configuration work did never result in a 'finished' product. Instead, a living, growing network develops between customer, product and company" (Engeström, 2004).

In this way, the product is under constant reconfiguration with regard to knowledge development among co-operating parties, and subsequently its use involves a redistribution of tasks and division of labor. In particular, the product assumes the latent quality of a boundary object:

> "The 'product' increasingly assumes a role of a boundary object between the cooperating parties functioning as a basis for coordination without any coordinating center. The cooperation takes the form of prob-

[47] As mentioned in Section 1.4.3 one difference between Fischer's conception of artifacts as boundary objects and the conception elaborated in the next section is that Fischer's considerations are based on a cognitive view, while I rest on an expressive view of artifacts serving as boundary objects.

lem oriented knotworking (Engeström et al., 1999) in which various specialists of the cooperating parties meet to create new solutions to emerging needs" (Virkkunen and Engeström, 2001).

Anderson and Mørch (2009) present an interesting attempt to combine Engeström's co-configuration and Fischer's Meta-design as an underlying theoretical lens to create an integrated model of EUD. They also make use of the concept of boundary objects. However they do not use it to systematically link the underlying ideas of Fischer's and Engeström's work.

In the work of Star and Griesemer, the role of boundary objects is as that of an analytical concept for reconstructing the translation process in the cooperative knowledge construction of actors from different social worlds. Methodologically, Star and Griesemer focus on historical examples of heterogeneous cooperation across different social worlds, where boundary objects are identified on the basis of an existing cooperation across social worlds. This is a historical study in which the researchers looking backward from the successful cooperation across social worlds to its enabling conditions. From this view, they identify the empirical objects that serve as boundary object enabling the cooperation.

A methodological approach in the spirit of Star and Griesemer would therefore look upstream in studying the artifacts that have served as boundary objects, e.g. in the cooperation between designer and users. I inverse this methodological approach, looking downstream in studying artifacts that *latently will serve as boundary objects* across social worlds. This allows for exploring from a phenomenological perspective the kind of social practices being mediated through a boundary object, and in doing so, we need to uncover the constitutive structure of what allows the appropriation of a boundary object. In particular, I am interested in the co-evolutionary nature of boundary objects and social practices. To explore this issue, I utilize a general concept characterizing boundary objects through the specific quality of social objects carrying more than one perspective at once.

This shift in perspective makes something explicit which is implicitly given by Fischer and worth further elaboration. Fischer remarks that in everyday life the use of artifacts connect us in various ways to social realities to which we intrinsically do not belong. Using social objects is therefore a constitutive act in the formation of cooperation across social worlds, where the social object serves as a boundary object. In my exploration of situated understanding of boundary objects, I will inquire into this constitutive role of artifacts for connecting different realities. In this view, the formation of cooperation mediated by the artifact can be conceived of forming of a boundary object, thus transforming the potential quality embodied by the artifact into actual quality.

Making something explicit that was implicitly given also holds for the work of Engeström and his considerations about the mediating role of products, which are themselves influenced by Marx's thoughts about the distributed nature of production and consumption in actual society. Explicating the underlying idea of Engeström's notion of usage we can specify use as a constitutive act, in which the artifact becomes boundary object across a heterogeneous cooperation among a product community, shaped by the specific cultural-material context of the usage situation.

Specifying the use of artifacts as a constitutive act for boundary objects can be studied from an external and internal perspective. From the external perspective we can explore how artifacts enable cross-world collaboration in exhibiting commonly appropriated objects generates a structure that is stable enough to enable collaboration, yet also plastic enough to respect the autonomy of the diverse social practices among a product community. From the internal perspective we can explore how the cross-world collaboration will be shaped through the appropriation of boundary objects in situated action. Both perspectives provide a complementary view on the duality of boundary objects as being medium and outcome of social practices. In the following, I explore the boundary object from an internal perspective, following the evolution of the appropriating of wicked situations.

4.2 Expressive quality of artifacts as a boundary objects

From a phenomenological perspective, the constitutive act for forming a boundary object is defined by the moment when the artifact becomes present-at-hand. In other words, a wicked situation of appearance provides the paradigmatic case for those kinds of boundary objects we are interested in.

Put briefly, a wicked situation in its appearing (Seel, 2005) has an evolutionary structure mediating social time and space. The here-and-now of the appearing can be identified with the concept of the present in general (Peirce, 1992b, first print 1877), given as a manifold, which irrefutably forces the identification. The appearing is the relative starting point for forming subject and predicate. The other side can be identified as the organically given synthesis of that manifold with a representation, thus connecting the potentiality of the present with a possible past and future. The expressive character of artifacts, which gleams in the constellation of the object's determination, is, therefore, rooted in the potentiality of the present, but refers to a possible world outside the present.

Analyzing the paradigmatic case we can identify some essential features of the boundary object. First of all, the boundary object inherits the evolutionary structure of the situation in

its appearing. In addition, in the situation of appearance the function of the boundary object is to mediate between a concrete subject and its environment in the continuous flow of action. Here, a corollary function of the boundary object is to mediate between past experience as potentialities and future action as possibilities. In mediating between future and past, the boundary object enacts its own evolution. The initial occurrence is accompanied by the constitution of a border between object and subject. In addition, the initial seed of the object's development is not a discrete entity, but has a recursive structure. This means that the initial state of the boundary object is the product of an evolutionary process, as well as the source for evolutionary progression.

This first introduction to the concept demonstrates that the artifact as it becomes present-at-hand fulfils the formal characteristics of a boundary object as described on page 100. In addition, it highlights the initial state of a boundary object as referring to the expressiveness of the embodied artifact. Hence, it makes sense to further elaborate on its expressive quality.

A more detailed analysis of the spatial and evolutionary structure of boundary objects will thus be conducted in the next section. It presents a theoretical model which is influenced by Schön (1984) and Rittel and Webber's (1974) considerations on reflective design processes. In particular, boundary objects will be interpreted from the perspective of wicked situation.

4.2.1 Spatial structure of boundary objects

Following the Marxian argumentation in Chapter 3, the subject-object relationship is constituted by the dialectic unity of appropriation of and realization in nature. In these dialectical processes artifacts are given as embodiment of meanings. However, an appropriated artifact will not be regarded as an individualistic, private object, but as an entity that inseparably sublates an own and a foreign property in its own constitution. Furthermore, the appropriation process is tied closely to the question of what is inside and what is outside.[48]

In Activity Theory, this aspect is taken up as key component of the dialectical unity of exteriorization and interiorization (cf. Leontjev, 1978, §1.148). I will take up the Marxian argumentation to study the localization of the expressive boundary object.

[48] This refers to the origins of the concept of appropriation (Aneignung) which first emerged in jurisprudents' discussions about general questions of property (cf. Section 3.1).

As first implication of being in the world, the self is postulated as center of a world construction. As second implication, the subject-object relationship is related to the question of what is inside and what is outside the subject. Being in the world is therefore linked to an inherently asymmetric inside-outside relation that constitutes a topological space.

This topological space allows for defining a boundary in a spatial sense. There are two different options for defining the boundary in this topological space. The first option is to define the boundary as an area that is neither located inside nor outside the subject. The other option is to define the boundary as an area that is located both inside and outside the subject. We choose the second option in order to localize the expressive boundary object.

The spatial structure can therefore be characterized by the following criteria:

Spatial features of expressive boundary objects:

I. Asymmetric Space: The subject being in the world is the center of a topological space, which is given by an asymmetric, transitive inside-outside relation.

II. Connectedness: The subject and its environment are not isolated entities, but connected with each other.

III. Boundary Area: The boundary area of a subject is specified as an area that belongs to the subject and the environment at the same time.

IV. Location of the Boundary Object: The expressive boundary object is located in this boundary area that belongs to the subject as well as to its environment.

An advantage of a topological characterization is its consistency with the evolutionary perspective outlined in my thesis, and the fact that inside and outside are not given by a fixed relation, but defined by a mutable boundary.

In particular, humans are endowed with the competence to determine the border of the inner and the outer world in a flexible way. Activity Theory takes the tool-object relation as a paradigmatic example, whereby the tool is part of the living body, while the object is part of the physical world. As mentioned above, Engeström makes us aware that “nothing in the material makeup of an object as such [...] would determine which one it is: object or tool. The constellation of activity determines the place and meaning of the object” (Engeström and Escalante, 1996, p. 361-362).

This quotation can be interpreted such that it is not just the physical reality which that decides whether something belongs to the own body or not. In other words, membership is not a monadic attribute, but a relative one, which is itself part of the socio-historical formation and appropriation process, so that the process has two directions: Making something one’s own describes the moment of interiorization, while making something own into a part of the external environment describes the moment of exteriorization.

From the perspective of exteriorization, it is therefore not very surprising that technology philosophers such as Kapp interpret technology as an extension of the human body and will, as organ projection, where tools are extensions of arms and legs, the railroad an extension of the circulatory system, etc. This perception provides something like a correspondence theory of technology, in which the organically grown human body is duplicated in engineered technology. In our context, the duplication of the body in the physical world can be interpreted as a special case of externalization.

However, our primary interest in such a perception of technology lies in the aspect of how the border between the own and the foreign body is drawn. The blurred border between inside and outside of the own can be used as the place where the spatial structure of the expressive boundary object can be localized.

From this perspective, Kapp's conception is interesting insofar as something that belongs to our organically grown human body now gains an autonomous reality, and in this process of realization the border between the own and the foreign has to be adjusted confront an open future.

From the perspective of interiorization, the discourse of embedded systems for human bodies raises new questions of human identity and the relation between humans and technology (Bürdek, 2005b, pp. 426). The initial idea of wearable computing was to bring computational technology closer to the human body. Taking up this initial idea and the new technical opportunities of embedded systems, Bürdek remarks that "it is quite natural to consider how wearables can get closer on or even into the human body" (Bürdek, 2005b, p. 429, translated by the author, Bürdek, 2005a, p. 429, translated by the author) He uses the term of 'implant design' to characterize this emerging field. Apart from technical and ethical issues, this field raises new design questions. Bürdek presents an implant design concept of Marc Behrens (see Figure 7) to illustrate possible applications in the future.

Figure 7 'The reader finger', implant design concept by Marc Behrens (illustration taken from Bürdek, 2005b)

Bürdek discusses this topic mainly from a design perspective. In order to discuss it from the perspective of interiorization, the case of boundary development for instance is also useful to take a look on studies on organ translation inspired by Merleau-Ponty's concept of body, such as Hauser-Schäublin . Merleau-Ponty differentiates between the phenomenological body, the objective body, and the physical world. In life, we are confronted with the need to create a body scheme that integrates the phenomenological and the objective body in a consistent way.[49] This need arises out of the fact that the phenomenological body (which undeniably belongs to oneself) has to be mediated with a physical environment (which undeniably does not belong to oneself). As a consequence, the body scheme has to construct a boundary between the body and its external environment.

Typically my organs belong to me, while this is not the case in respect of artificial organs or the organs of someone else. Therefore, organ transplantation typically presents a fundamental disruption of the internal/external border, where the (trans-formation of the) border between own and foreign can literally become virulent. This is why studies on organ transplantation can be of interest here, illustrating general aspects of appropriation processes. The transformational character of this process can be observed, for example, in an interview with an organ transplantation patient about the exposure of the own body:

> "I've never spoken with the kidney. No, initially I've felt it as foreign body, purely anatomically [...] And by the time I no longer felt that, so in principle I do not perceive the kidney anymore.. I perceive it only if it hurts sometimes, when the weather changed perhaps, but here I am not so sure" (transcript taken from 2001, p. 130, translated by the author).

This quotation illustrates the privation of an existing body scheme. In such moments the body's feature as self-contradicting unity of a phenomenological and an objective body becomes relevant. In particular, maintaining one's own identity while transforming the self becomes a vital aspect of the appropriation process. The transcript also demonstrates the plasticity of the border between inside and outside in life praxis. Furthermore, the case of organ transplantation demonstrates that `developable` should not be misunderstood as a process about which the subject has full control.[50] Further, it also demonstrates that the question of whether an implant is a contingent object in the body or if it is an essential part

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[49] Although entering another very interesting path to elaborate the concept of expressive boundary objects, for reasons of space and time this work cannot follow this path in detail. A more detailed comparison between Mead's post-Cartesian pragmatism and Merleau-Ponty's post-Cartesian phenomenology is provided by Rosenthal and Bourgeois (1991).

[50] In the next section an evolutionary model will be outlined that interprets appropriation as a process that has an organic as well as a rational moment.

of the body cannot be answered on the level of the material makeup of an implant. Rather, it is a relational attribute referring to the outcome of an open process of appropriation. In addition, this process is also affected by the socio-historical constellation (e.g. the prevailing religious interpretation scheme, the contemporary state of the art of technology, etc.).

Of course, organ projection and organ transplantation are extreme cases. However, they stand for limiting cases that amplify a general structure, which can be also identified in the appropriation of artifacts in everyday life. In order to illustrate this point, I will give an example Dourish used in his book on embodied interaction:

> "As an example, consider the mouse connected to my computer. Much of the time, I act through the mouse; the mouse is an extension of my hand […] The mouse becomes the object of my attention as I pick it up and move it back to the center of the mousepad" (Dourish, 2004, p. 109).

The key issue in the phrase "the mouse is an extension of my hand" is that it addresses both organ projection and organ transplantation. From the perspective of organ projection, the mouse projects moves of my hand into the digital world. From the perspective of organ transplantation, the digital world becomes part of my own through the help of the mouse. In both cases, the mouse as artifact is localized at the boundary of the own and the foreign.

The place at the border becomes clearer if we take a look at the whole situation. At one moment, the mouse as an artifact is a part of the own body, while in the next moment, the artifact is inspected as a foreign body. This example highlights the competence of man for situational control of the border between own and foreign body. Through this competence, it is possible to temporally make the artifact a part of the own body, as well as a part of the foreign body. In this process, the artifact oscillates temporally between the limiting case where technology is externalized and separated from the own phenomenological body, and the limiting case where technology is internalized and completely integrated into the own phenomenological body. In particular, the spatial dimension of the expressive boundary object is at the threshold between these two limiting cases.

The general feature of the boundary object to mediate between different perspectives refers in this context to the feature that in a breakdown situation, the artifact carries both the perspective of the own body and the foreign body at once. In particular, artifacts are physical embodiments of human subjects or, more precisely, they lie at the border of the self. The spatial dimension of the expressive boundary object characterizes the connection between the artifact as an element of our phenomenological body, and the artifact as element of the physical world. Therefore, artifacts are inseparably connected with a body scheme, and a breakdown situation can therefore also be characterized as a disruption of the prevailing body scheme.

4.2.2 Evolutionary structure of boundary objects

The previous section explicated the expressive boundary objects as wicked situations in their appearing to mediate reflective actions. The situations of appearance simultaneously mediate between own and foreign body as well as past and future. Thus, they have a spatio-temporal dimension. In order to figure out the temporal structure, I will take a dynamic view on design as suggested by Schön (1984) and Rittel and Webber (1974) and look at boundary objects from a Pragmatist understanding.

Schön (1984) argues that design covers a moment of reflective conversion with the situation. This reflective conversion with the situation is initiated, first of all, by the appearance of a problem as a synthesis of manifold givens in the present situation:

> "In the real-world practice problems do not present themselves to the practitioner as givens. They must be constructed from the materials of problematic situations which are puzzling, troubling, and uncertain. In order to convert a problematic situation to a problem, a practitioner must do certain kind of work. He must make sense of an uncertain situation that initially makes no sense […] When we set the problem, we select what we will treat as the 'things' of the situation, we set the boundaries of our attention to it, and we impose upon it a coherence which allows us to say what is wrong and in what directions the situation needs to be changed. Problem setting is a process in which, interactively, we *name* the things to which we will attend and *frame* the context in which we will attend to them. Even when a problem is constructed it may escape the categories of applied science [or the existing beliefs manifested in settled routines respectively] because it present itself as unique or unstable" (Schön, 1984, p. 40).

Schön's (1984) description of the problem's framing as denominating things to which we will attend represents a special case of Peirce's (1992a, first print 1877) semiotic considerations on reducing the manifold of sensory impressions to one unity.

Studying the constitution of the objects of our experience, Peirce (1992a, first print 1877) emphasizes that the logical structure refers to a dualism of two realities mediated by a third. These two realities are given by an ontic or material *it* as the present world, and by an ontological or social *being* as the conceptual construction of the world "which were relating to each other by the mediation of synthesizing practice, but categorically not convertible into each other" (Oevermann, 2001b, p. 221, translated from the author, Oevermann, 2001a, p. 221).[51]

In particular, Peirce's triadic conception can be used to characterize the dialectic unity of artifacts as materially and meaningfully constructed objects as well as the wicked design

[51] We found a similar point of view in Cole, who bears a close affinity to Dewey, Hegel and Marx: "By virtue of the changes wrought in the process of their creation and use, artifacts are simultaneously *ideal* (conceptual) and *material*" (Cole, 1996, p. 116).

situation of Schön's reflective practitioner. More precisely, we can locate Schön's problem framing between the general case of synthesizing the manifold of impressions to unity, and the specific case of making sense of the material artifact elaborated in this thesis.

Schön's structural characterization of the problematic situation has the spatial form of a boundary object as outlined above. In addition, the problematic situation has an inherently temporal structure. The appearance of the situation is rooted in a process of problem framing that is linked with the question in which directions the situation needs to be changed. Moreover, the situation has a temporal character, where reflection-in-action and changing the construction of the environment is inseparably connected. In other words, in the moment of situated action, the subject and its actual environment are not only spatially, but also temporally connected.

In the appearance of the problematic situation, options for changing the situation also come to the fore. These options emerge out of the present situation (and insofar refer to the subject as well as to the actual environment). In addition, options also mediate between past and future insofar that they are the result of past situations, but directed to future situations. This means that the appearing options are based on the expressive boundary object, constituting the temporal dimension.

What in Schön's analysis of the phenomenon is denoted as *problematic situation* and that I call *wicked situation*. Reflection-in-action cannot be reduced to deliberate action based on the settled routines. Instead, it is comprehensible through the flow of the situation, where the actions get a form of a conversation with the situation present-at-hand. In particular, the wicked situation is characterized by an increased attention to appropriate the emerging object appears[52]. To overcome the wickedness of the situation the practitioner's actions must produce changes that he has not entirely under control, while the situation takes the opportunity talk back. In this process the situation will be reframed:

> "As the practitioner reframes the […] problem, he suggests a direction for reshaping the situation. […] The practitioner then takes the reframed problem and conducts an experiment to discover what consequences and implications can be made to follow from it […] In order to see what can be made to follow from his reframing of the situation, each practitioner tries to adapt the situation to the frame. This he does through a web of moves, discovered consequences, implications, appreciations, and further moves. Within the larger web, individual moves yield. This he does through a web of moves, discovered consequences, impli-

[52] More precisely the emergent lies in the boundary area between the subject and its environment or shortly in the wicked situation itself, therefore I also argue that the situation is characterized by a increased experiencability to express that in such situation the chance is increase to get aware of foreign objects in the own reality construction.

cations, appreciations, and further moves. Within the larger web, individual moves yield phenomena to be understood, problems to be solved or opportunities to be exploited" (Schön, 1984, p. 131).

This consideration on the situated action of reflective practitioners can be applied to the temporal structure of expressive boundary objects. Following Schön, the expressive boundary object as a problematic situation does not just have a temporal structure, but is only constituted through its evolutionary flow. The evolutionary flow itself is formed through the progressive development of the situation in which the situation also transforms its identity.

So the static structure of expressive boundary objects presents an analytical abstraction of their essential flow structure. The flow structure means that boundary objects not only occupy an interval of time, but also represent a lapse of time. Secondly, the expressive boundary object presents a source and realization of its own progressive development by mediating between its past and its future. This topic can be captured by an evolutionary structure, which has not just a temporal dimension, but a temporal dimension given by a recursive, asymmetric and self-similar structure.[53]

In the case of a problematic situation we can further distinguish between two types. The first type is the class of standard problems, where the process of problem solving can be reduced to the application of existing routines. The second type is the class of innovative design situation where the settled routines do not work. Schön's considerations refer to the second case, where the reflective practitioner treats his case as unique, and thus cannot deal with it by applying standard theories or techniques. Such problematic situations are structurally related to Rittel and Webber's (1974) wicked problems.

Rittel and Webber (1974) characterize wicked problems by a set of features. One of the essential features of wicked problems is that they cannot be translated into a definitive specification without interpreting the situation in the light of a possible solution. In other words, problem framing and problem solving are inherently connected, constituting a dialectic unity in the flow of action:

"The information needed to understand the problem depends upon one's idea for solving it. That is to say: in order to describe a wicked-problem in sufficient detail, one has to develop an exhaustive inventory of

[53] In his phenomenological analysis or categorical analysis respectively, Peirce (1992b) studied such recursive, asymmetric self-similar structures to determine the constitutive structure of the objects of our reality (see also Müller, 1999, Baltzer, 1994). His analysis is quite helpful to characterize the evolution of an expressive boundary object in its meaningful construction. However his model of the constitution of objects should be interpreted in a broader sense in order to take also the material evolution of (boundary) objects into account.

all conceivable solutions ahead of time. The reason is that every question asking for additional information depends upon the understanding of the problem - and its resolution - at that time. Problem understanding and problem resolution are concomitant to each other. […] The formulation of a wicked problem is the problem! The process of formulating the problem and of conceiving a solution (or re-solution) are identical, since every specification of the problem is a specification of the direction in which a treatment is considered" (Rittel and Webber, 1974, p. 161).

Another essential feature is that each wicked problem is essentially unique. Unique in this respect not only means that a wicked problem has some individual, and some accidental features, but that it is unique by preventing standardized problem solving:

"[B]y 'essentially unique' we mean that, despite long lists of similarities between a current problem and a previous one, there always might be an additional distinguishing property that is of overriding importance. […] There are no classes of wicked problems in the sense that principles of solution can be developed to fit all members of a class. In mathematics there are rules for classifying families of problems - say, of solving a class of equations - whenever a certain quite-well-specified set of characteristics matches the problem. There are explicit characteristics of tame problems that define similarities among them, in such fashion that the same set of techniques is likely to be effective on all of them. Despite seeming similarities among wicked problems, one can never be certain that the particulars of a problem do not override its commonalities with other problems already dealt with" (Rittel and Webber, 1974, p. 164).

The most important consequence of the non-standardizable character is that Rittel and Webber's designing in reaction to a wicked situation cannot be reduced to the application of an algorithmic problem solution, since dealing with wicked problems cannot be reduced to the moment of obeying a rule in a mathematical sense. Instead, dealing with wicked problems is a situated action in the sense of Suchman (1987), where in the present situation plans – as synthesis of past experiences – are a resource, but still they cannot be understood as the mechanism that drives the flow of action. Moreover, the concept of wicked problems not merely emphasizes the situatedness (as by Suchman, 1987), but also the historicalness of action creating ontic as well as epistemic traces:

"Every solution to a wicked problem is a 'one-shot operation' […With wicked problems] every implemented solution is consequential. It leaves 'traces' that cannot be undone. Whenever actions are effectively irreversible and whenever the half-lives of the consequences are long, every trial counts. And every attempt to reverse a decision or to correct for the undesired consequences poses another set of wicked problems, which are in turn subject to the same dilemmas" (Rittel and Webber, 1974, p. 163).

Rittel and Webber mainly focus in this quote on the ontic traces that are based on the fact that changes in the material construction cannot be undone. However, the evolution of wicked situations does not merely leave ontic, but (among others) also epistemic traces. This second point is implicitly stated by Rittel and Webber addressing the 'Aha' effect in the

process of formulating a wicked problem: “Aha! That's the locus of the difficulty” (Rittel and Webber, 1974, p. 161).

The ‘Aha’ effect did not only describe the resolution of a well-structured problem, but also a moment in the constitution of the problem. The utterance of the ‘Aha', therefore, refers to the occurrence of an event when we see the problem in the light of a solution. This co-constitution of problem and solution is described by Rittel and Webber (1974) as follows:

> “If we can formulate the problem by tracing it to some sorts of sources […] then we have thereby also formulated a solution. […T]he problem can't be defined until the solution has been found.” (p. 161).

The ‘Aha’ effect is normally accompanied by an epistemic event that makes it hard to reverse the effect of the emergent event and seeing the problem as it was before the event occurred.[54] So, the epistemic event is consequential for the evolution of the wicked situation. In this sense, the evolution of the wicked situation did not just leave merely an ontic but also an epistemic trace that cannot be undone after completion, since the “present is always in some sense new and abrupt, but once it has occurred, we start on the arduous task of reconstructing the past in terms of it” (Järvinen, 2004).

The evolutionary wicked situation can therefore neither be reduced to a subject nor to its environment, but is located at the boundary area between both. It is given as a flow of situated actions, where the evolution refers to a web of moves, discovered consequences, implications, appreciations, and further moves.

Another topic discussed by Rittel and Webber (1974) is the problem of evaluating the progress in the evolution of a wicked situation. The starting point of their reflection is the analysis of a well-structured problem. In this case, the evaluation of the progress does not pose a problem:

> “There are conventionalized criteria for objectively deciding whether the offered solution to [well structured problems] is correct or false. They can be independently checked by other qualified persons who are familiar with the established criteria; and the answer will be normally unambiguous” (Rittel and Webber, 1974, p. 162).

However, the uniqueness of a wicked situation also comprises the absence of conventionalized criteria to evaluate the progress in the situation’s evolution: In particular,

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[54] Typically, the “Aha”-utterance refers to an event that leaves an epistemic trace on a micro-level. On a macro-level, analogue cases of epistemic traces can be found on the appropriation example discussed on page 80. In the case of Marx’s example of music that awakens in man the sense of music, as well as in the case of Pipek’s example of appropriating mobile technology, the ontic and epistemic traces are inseparably connected.

> "[there is] no immediate and no ultimate test of a solution to a wicked problem [… and that] the full consequences cannot be appraised until the waves of repercussions have completely run out" (Rittel and Webber, 1974, p. 163).

The evolution of the wicked situation therefore also presents an evolution of the criteria that are needed to evaluate the progress. In other words: there are wicked situations, for which only a retrospective evaluation of their evolution is possible, even in situations in which the reflective practitioner "has no right to be wrong" (Rittel and Webber, 1974, p. 166). In such situations the dilemma is that criteria for acting are not available. However, one cannot act arbitrarily, as the flow of action presents a "one-shot operation" that leaves an irreversible ontic trace.

The absence of conventionalized criteria, following Rittel and Webber (1974, p. 166), has the consequences that solutions to wicked problems are not true or false, but good or bad.

However, this does not solve the dilemma. Or, more precisely, Rittel and Webber do not reflect on the dilemma that there are wicked situations where no conventionalized criteria are available to decide which of the given change options are good or bad. Consequently, structural dilemma of wicked situations cannot be solved by replacing the right-wrong schema with a good-bad schema. An alternative solution is provided by the Pragmatist position of Oevermann .

In his view, the structural dilemma presents an essential element of situated actions as a contradictory unity of making decisions in the flow of (wicked) situations ("Entscheidungszwang") and the obligation to give reasons ("Begründungsverpflichtung"). In the theory of Oevermann, a wicked situation presents a crisis which constitutes the structural autonomy of a life practice. In his theoretic framework a crisis characterized by the fact that:

> "[One has to decide although] there are not any established criteria available to judge between right and wrong. Still, in the long run reasons for taking this distinction are typically required. Since criteria to access a decision's rationality are not available, a decision taken can neither be judged as rational nor as irrational in the moment of its execution" (Oevermann, 2008b, p. 22, translated from the author, Oevermann, 2008a, p. 22, translated from the authors).

Oevermann's theoretic framework is founded on Peirce and Mead's Pragmatist studies of the phenomenon of the present as the locus of emergence. However, the conception of an emergent present is confronted with an objection which can be labeled as the problem of situated singularities. Thus, "the subject and object relation, the ego and alter, would have disappeared temporarily within this field [… as] the distinction between subject and predicate cannot be made" (Mead, 1981, p. 52). This also means that the rules for action appear and evolve in the moment of the actual situation. This raises the question of how the situ-

ated action as an element of the present is connected to the world that is outside of the present situation.

Structurally, the problem of situated singularity can be mapped to the problem of private language, where “the individual words […] refer to what can only be known to the person speaking, to his immediate sensations” (Wittgenstein 2002, § 243). The problem of the private language is that it cannot accept any opposition, thus, it makes no sense to argue about whether one allegedly obeys the rules of the (private) language or not.

In the same way as the situated singularity can be mapped to the problem of private language, it can be mapped to the problem of how situated actions are connected with plans as elements that transcend a situation.

Here, one can roughly distinguish between three approaches in the literature. The first one locates the rules on a mental level, thereby assigning them a causal function for the explanation of human behavior. The second position entirely abstains from referring to rules to explain human conduct. The third position understands rules as an independent social reality, which cannot be expressed in terms of a causal relationship but which is nevertheless inseparably connected to human action. Regarding the first two positions, the limit case would not posit a problem, since in the first case the presumption *‘in absence of any plans that guided the action’* would be challenged. In the second case, the limit case would not even be recognized as a problem. Both approaches, however, fail to take appropriate account of action that deviates from the norms as well as of the evolution of new norms. If a causal relationship between rules and behavior is postulated, deviation is excluded by definition. If a connection between rules and behavior is principally denied, deviating actions cannot be explained by reference to rules. Since deviation from established norms and the evolution of new norms is in the focus of appropriation research, the third position moves into the centre of attention.

Peirce’s concept of semiotic processes as a continuous mediation that connects intentional and extensional reality can be interpreted as representative for the third strategy. Inspired by Peirce’s work, a strategy to overcome the problem of situated singularities is to introduce the continuity of practice that always refers to a before and an after of the dialectic of organic action and self-reflection in action.

More precisely, from a Pragmatist point of view, the phenomenon of situated actions can be studied from the category of deliberation, as the appearance of options (potentiality), the

category of realization of an option (actuality), and the category of rule-following[55] (generality). The totality of situated action is grounded in these categories as its irreducible constitutive elements.

The manifestation of different categories will usually collapse in routines, but in the moment of crisis, the drifting of categories becomes visible, thereby demonstrating that these aspects constitute a contracted unity.[56] From such a perspective, the evolution of conventionalized criteria in wicked situation is analogue to the privation of a rule or a habit superseded by one that is shaped in the evolution of the situation:

> "It [the doubt in reaction to a doubtful or wicked situation] is not a habit, but the privation of a habit. Now a privation of a habit, in order to be anything at all, must be a condition of erratic activity that in some way must get superseded by a habit" (Peirce, 1998a, p. 337).

The evolution of a wicked situation presents a co-evolution of the subject and its environment, linked to a flow of organic and self-controlled action. Here, the obligation to give reasons is an essential moment in the flow of action. However, the flow cannot be reduced to that moment. Instead, the flow of action presents a continuity which has a blurred border between organic and self-controlled reflection. Or as stated by Peirce (1998b) the wicked situation "must be the condition of erratic activity that in some way must get superseded by habit" (p. 337).

This means that the evolution of wicked situations shares many similarities with the logic of abductive reasoning, as Peirce emphasizes: "abductive inference [a self controlled reason-

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[55] Obeying a rule refers to Peirce's category of habits as a Thirdness. A habit is "a general law of action, such that on a certain general kind of occasion a man will be more or less apt to act in a certain general way" (Peirce et al., 1987, § 1.148). However, one should not misinterpret a habit as a behaviorist concept, where realization of action is just a mechanic application of rules. Instead, it mediates between potentiality and actuality of action in a general way. In particular, habits themselves can emerge and be transformed in an evolutionary process of action.

[56] Deliberation is not located at the point in time prior to the realization of an action. Instead, a situation of action is constituted by deliberation, realization and rules of action as contradictory unity of social time. At this point, Suchman criticizes the pragmatist position: "Mead's treatment of the relation of deliberation and reflection to action is one of the more controversial and in some ways incoherent, pieces of his work" (Suchman 1987, p. 51).

However, this criticism can only be understood if deliberation is denied as a category which rests upon social reality. Suchman's considerations on plans and situated actions are a seminal work in criticizing the naturalistic position of AI research. Unfortunately, it is difficult to determine her theoretical perspective on deliberation. Hence, it is also difficult to judge whether this criticism is an expression of her position, a misunderstanding of Mead's position or just a remark on the acceptance of a pragmatist position in the scientific community.

ing] shades into perceptual judgment [an organic inferring[57]] without any sharp line of demarcation between them" (Peirce, 1998a, p. 227) and “we never can be absolutely sure that a judgment is perceptual and not abductive” (Peirce, 1998a, p. 230).

Summing up, Schön (1984) as well as Rittel and Webber (1974) provide a dynamic perspective on design. They use the problematic situation (Schön) respective the wicked problem (Rittel and Webber) as a paradigmatic case to elaborate the underlying concepts. Analyzing the essential structure of the paradigmatic case, they demonstrate design intention and design situation to be inseparably connected and to co-evolve in the continuous flow of action and reflection. In particular, Rittel and Webber (1974) have pointed to a fundamental design dilemma especially in innovation development[58] resulting from the absence of conventionalized criteria for right and wrong. However, their suggestion to replace the right-wrong schema by a good-bad schema merely shifts the dilemma to a different context, but does not provide an appropriate theoretical understanding of the dilemma itself. The brief outline of the concept of situated actions based on Peirce’s dynamical semiotic-logic conception of action (cf. Müller, 1999, Baltzer, 1994) shows a possible direction to repair Rittel and Webber’s conception at this point, by providing a Pragmatist concept of wicked situations.

However I do not address this issue in detail, but rather use the brief outline to sensitize a Pragmatist view on design as the evolution of a wicked situation that covers a co-evolution of subject and object. In particular, I will use wicked situations as a paradigmatic case to characterize the evolutionary structure of boundary objects.

From a Pragmatist view, the dialectic of appropriation and realization is linked to the concept of wicked situations constituting a space for situated actions. This space has the characteristics mentioned on page 108, but also an evolutionary character. The expressive

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[57] In Peirce’s work, inferring and reasoning have an identical structure. Both translate a premise into a conclusion by virtue of an inference rule or more precisely to mediate between an object [premise] and an interpretant [conclusion] by virtue of a representamen [inference rule]. However, inferring describes any mental operation that has a semiotic structure, while *“*reasoning is deliberate, voluntary*,* critical, controlled, all of which it can only be if it is done consciously” (Peirce et al., 1987, § 2.183).

[58] In particular, the dilemma characterizes the constitutive structure of innovation development in its generality. The romantic idea of self-empowerment (Selbstermächtigung) (which was later adopted by Schumpeter in his notion of the dynamic entrepreneur and by Weber in his notion of charismatic leadership) presents one and maybe not the best solution to deal with the dilemma practically.

boundary object is located in this space for situated actions, inheriting the evolutionary features of wicked situations.

Moreover, the wicked design situation in its formal structure satisfies the structural demands on boundary objects specified on page 108. In particular, in its subject matter the wicked design situation can serve as paradigmatic case for the evolutionary model of boundary objects. Therefore, some key characteristics of wicked situations as evolutionary spaces will be summarized in the following paragraph:

Characterization of evolutionary structure of wicked situations as places for boundary objects

I. Asymmetric connectedness on man and environment in wicked situations: In a wicked situation, the subject and its environment are connected by a continuous flow of action. Moreover, a wicked situation represents an evolutionary space with a spatial structure analogue to the boundary space defined on page 108.

II. Self-similarity of structure in a continuous flow: A present situation of action is cut in the wicked situation. The cut thus created is not an isolated entity, but connected with the continuous flow of action. In other words, a cross-section is in itself an evolutionary space. This means, situations of action in their totality have a self-similar structure, so that a flow of action can be analyzed in a way as obeying situated rules is itself embedded in a flow of obeying rules in a situated manner, and yet consists of a flow of situated rule following, thus attaining stillness at the level of identity by constant movement (like an Escher print or the flow of Zeno's tortoise).

III. Processual mediation: As a flow of action, a situation of action is given by a hierarchical, triadic relation of mediating the past and the future in the present. The flow does not merely mediate between past and future, but in doing so constitutes the location in the present where the past transitions into the future.

IV. Relative-progressive development: The asymmetric structure of space also means that the subject's perspective is constitutive of a wicked situation. As a consequence of being thus perspective-bound, the space is impregnated with intentionality. Therefore, the evolution does not just present a mechanic process, but a transition that is associated with the moment of deliberation. Hence, the evolution of a wicked situation is not just the change of a situation, but presents a non-reproducible process that refers to the moment of progression. An essential element in the evolution of a wicked situation is the continuous flow of situated actions in their aforementioned triadic relation of potentiality, actuality and generality.

V. Evolutionary structure of boundary objects: Expressive boundary objects are sources for and objects of situated actions. They are localized in situations of action, and co-evolve with them in the continuous flow of action. The evolutionary structure of expressive boundary objects describes a contradictory unity of erratic activity and self-controlled development.

After this discussion of form, I want to explore the subject matter of the expressive boundary object.

As mentioned before, my research interest is to figure out the mediation structure of situation present-at-hand as a meaningful object that represents a contingent socio-material construction. Moreover, the appearance of artifact present-at-hand in reflective action presents the paradigmatic example of the evolutionary boundary object. In this context the formal characterization of expressive boundary objects assumes that there is an evolutionary center. In the case of the artifact present-at-hand, the center can be characterized by the point of infrastructure (Pipek and Syrjänen, 2006, Pipek and Wulf, 2009), related to the moment of genuine doubt when the wicked situation appears with a surprise that initializes dissolution.

The evolutionary center is given by the artifact's potentiality holding the rising habit gleamed in surprise, and the falling habit gleamed in dissolution. While the beginning can be characterized as potentiality, a preliminary end of the evolution is given when initial doubt is superseded by a factual belief. This might be the case when a new artifact-use connection is established by a superseded embodied habit.[59]

In the case of the artifact serving as boundary object, such an evolution is linked to co-evolutionary processes of the artifact on the material level as well as on the level of meaning.

The asymmetry in the evolution of the expressive boundary object is be spelled out by the fact that the rationality of its evolution can be reconstructed through a retrospective analysis of its genesis. In contrast, in the paradigmatic case of a wicked situation, the evolution cannot be reduced to the moment of rational decision based on conventional criteria. Instead, from the perspective of the continuous flow of action, the evolution of the wicked situation is given by situated actions as a contradictory unity of deliberation, realization, and obeying rules.

Because of the asymmetrical structure, one has to distinguish two different perspectives on the evolution of wicked situations. The first one is the genetic perspective, which explores the development process in its chronological order. It follows the order of the actually realized decisions in the situated action, and explicates the possibilities and the scope of action

[59] Overcoming a wicked situation in an innovative way can also be characterized as the *dialectic unity of creative destruction of habits.* However, because of the destructive character of breakdown situations, they should be prevented in practice (especially if they involve injury to the human psyche), but at the same time, they constitute an essential element for knowledge development, and a source for human evolutionary growth.

Such a pragmatist conception of the evolution of wicked situations also reveals a close relationship to Engeström's (1987) conception of expansive learning, and leads to a similar assessment as Pipek and Syrjänen's (2006) analysis of breakdown situations.

present within the potentiality of the actual situation. The second is the normative perspective, which takes the result of the process into account. This perspective judges the rationality of the process's result in the light of the knowledge newly gained through attaining the result. In contrast to the genetic perspective, the normative perspective is not primarily interested in the genetic constitution of the chosen path, but instead focuses on logical justification and foundational circumstance.

The genetic perspective tries to reconstruct the perspective of life praxis, explicating options of actions that become available in cuts of an actual wicked situation. However, such a reconstruction explicates only potentialities given in the situation, not the options that are intentionally given by the subject. Second, the decision-making cannot be deduced from a reconstruction of potentialities; instead, the reconstruction of potentialities only provides a foil to identify the rationality of a decision that has already been made in practice. Making a decision is inherently rooted in a life practice, and thus not located in the analytical sphere. The principal need to root decision making in practice is demonstrated by Wittgenstein's analysis of rule obeying as well as Peirce's analysis of knowledge development as rooted in perceptual judgments. In our case, the topic becomes relevant, for if we search for a theoretical model of design to describe a wicked situation, running into aporias cannot be avoided once this locating of a practical action in the analytical sphere is attempted.

The evolution of a wicked situation in general can therefore only be characterized by its form, while in its content, a specific evolution can only be analyzed in a reconstruction-logical manner.

A methodological consequence of this issue will be that design research presents a kind of Action Research with a practical and a theoretical side. In their role as designers, Action Researchers are inside a life practice which constitutes the organic centre of the evolution of wicked situations.[60] Beyond its form, a theoretical reflection on evolutionary boundary objects mainly has a heuristic value.

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[60] As outlined in Section 1.2, the practical facet can be characterized by Alan Kay's quip that the best way to predict the future is to invent it. In their role as scientists, Action Researchers are outside this life practice, analyzing in a retrospective manner the general rationality of a successful solution which emerges in the evolution of a wicked situation. As Hegel reminds us, the owl of Minerva flies only at dusk. In particular, design research should study cases of successful overcoming of wicked situations, and the evolution of processes in both directions at the same time: One eye has to follow the chronological order of the realized formation of objects, and the possibilities that arise along this path; the other eye has to reconstruct the decision process in the light of the attained knowledge.

Nevertheless, we ask on a theoretical level which options appears in situations where an artifact becomes present-at-hand. In the very beginning of such a situation, the boundary area collapses to one point, so that the relation between subject and object temporarily disappears.[61] Taking the considerations of Section 4.2.1 into account, this means first of all that a breakdown creates doubt on the border between the own and the foreign.

In order to overcome a breakdown, the wicked situation as an expressive boundary object has to be transformed. From an epistemic view this can be done by changing the meaningful construction, from an ontic view this can be done by changing the material construction. This means at least two options arise in the appearance of a wicked situation. In addition, taking into account that the wicked situation refers to an artifact as a means for an end, we can identify three basic options:

- **changing the means in its material construction by leaving the ends fixed**

  Such a transformation of the sign can be illustrated by the case of a broken mass-produced object (e.g. an alarm clock), which is replaced by another instance of the same mass produced product (perhaps made by a different worker). Except for this change in specific material object, there are no (persistent) amendments of the phenomenological artifact, especially of how and for what purpose the artifact is used.

- **changing the means in its meaningful construction by leaving the ends fixed**

  Such transformations describe from an inside perspective the common notion of adoption of artifacts as learning the correct use of the functionalities of a software system. In this process, the character of the artifact remains the same. The change occurs on the (functional) level of making use of the means provided by a given artifact to reach a pre-existing end. For example, if the alarm clock is replaced by a different alarm clock, then a breakdown situation may occur if the design of the new clock is slightly different from the previous one. Here a breakdown situation may be overcome by learning how the old function (e.g. setting the alarm to 7am) can be realized with the new product.

- **changing the ends associated with the artifact in question**

  Such transformations describe the appropriation of artifacts in the narrow sense of the word that also affect the character of the artifact itself. In Pipek's story about mobile phone appropriation, there is such a moment when the needs and purposes which are represented by the mobile phone are transformed (cf. Pipek 2005).

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[61] In the empirical study below, this logic-theoretical argument could be found in the observation that initially the occasion of the incident could not immediately be localized, but the localization was part of the inquiry process.

Analytically, the distinguishing feature between the second and the third option is given by the question whether in the process the identity of the artifact will be transformed.[62] The essential point however is not whether the identity has been changed for an external observer, or that the artifact is used in an unanticipated way. The essential point here is the process of immanent transformation of the artifact's identity.

The aim of the Appropriation Infrastructure is to support situated development through the support of the users as reflective practitioners in the further development of the artifact and their practices. Therefore, it is interesting to analyze the occurrence of wicked situations where the artifact serves as an expressive boundary object.

From the Pragmatist point of view, occurrences of wicked situations are related to the inhibition of action accompanied with the privation of a habit. Heuristically situated development in reflection can be characterized as the privation of a habit (Peirce), the (temporary) inhibition of action (Mead), as a disillusioning and surprising situation (Peirce), or a doubtful situation (Dewey). In particular, in his logical considerations on abductive knowledge development, Peirce works out two typical situations with respect to the occasion of experience.

The first type refers to the *situated development in pressure*. It occurs when existing habits are smashed by an immediate practical problem which nevertheless and unremittingly waits to be solved. Such a situation is characterized by the high probability of making a risky guess, because of the urgent need for a new habit. The bad experience motivates to break away from old habits to tackle the problem. Peirce illustrates this type by the anecdote of somebody having stolen his valuable clock. He is in highest need to catch the crook by an instinctive, risky guess (cf. Paavola, 2005).

The second type refers to the *situated development in pleasure*. It occurs in relaxed situations where almost no immediate need exists to stick to old habits, while there is enough space to experiment with new beliefs and having the appropriate aesthetical material at hand to make new experiences in the play of beliefs (see Section 1.4.2). Peirce illustrates this type by moments of *musement* „as a pure and disinterested game which has no objectives" (Nubiola, n.r.). In other words, one can distinguish moments where new ideas are needed immediately to handle an unexpected situation from moments where one can try out new ideas to put them in a repository for further use.

[62] This aspect is closely related to the question of the transformation of the spirit of technology, which in my eyes is not appropriate solved in the Adaptive Structuration Theory (AST).

These ideal types can be used heuristically, to characterize typical situations for situated development. The first situation can be identified with the breakdown situation described by Pipek and Syrjänen (2006), or with the traumatic crisis mentioned by Oevermann . The second one can be identified by situations of innovations as set out by Pipek and Syrjänen (2006) or with the aesthetical crisis described in Oevermann (2008b).

The theoretical model of the evolutionary structure of wicked situations (see page 121) provides a direction regarding the study of users' activity in reaction to the occurrence of a wicked situation. In particular, the theoretical model indicates that a model of correspondingly situated actions should take the co-evolution of ontic and epistemic traces into account. Such a model is given by Dewey's (1938) theory of inquiry.

Like Peirce's argument for the primacy of genuine doubt in philosophical endeavors, Dewey perceives doubtful situations as starting point for any serious scientific inquiry. For Dewey, the characteristic of a doubtful situation is the privation of habit, if the concrete subject of experience is confronted with an entirely doubtful situation. In Dewey's discussion of his theory of inquiry, he examines the philosophy of science from this perspective. Based on this understanding, he defines inquiry as

> "the controlled or directed transformation of an indeterminate situation into one that that is so determine in its constituent distinctions and relations as to convert the elements of the original situation into a unified whole" (Dewey, 1938, p. 108).

From this point of view, he searches for the pattern of inquiry. He works out five stages which relate to each other in a self-recursive process of the inquiry. A schematic view of these five stages is given as the cyclic model of inquiry, presented in Figure 8.

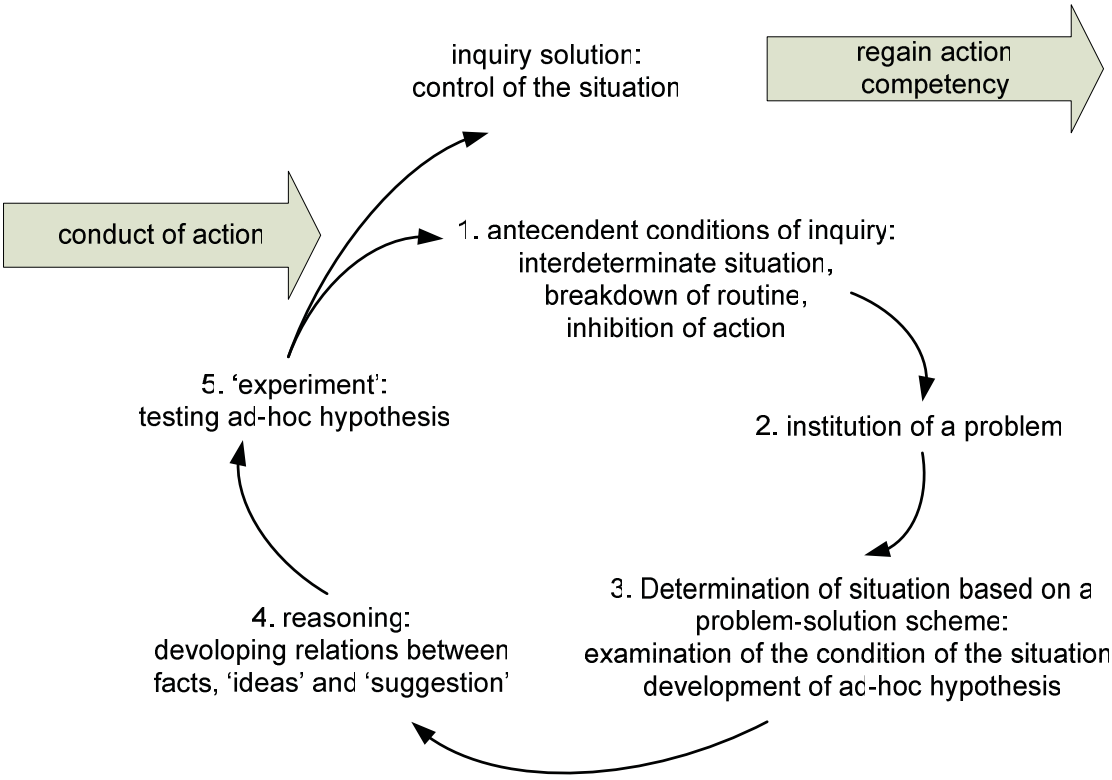

Figure 8 A schematic view of the pattern of inquiry as a cyclic problem solving model (taken from Strübing, 2005)

Dewey leaves the question open whether these stages should be regarded as constitutive principles, as a regulative idea, or as a heuristic framework to describe how researchers as practitioners typically act. Although many questions in the philosophy of science are left unanswered by such an interpretation, it makes sense to understand this pattern of inquiry as a rationalized version of common practices of acting in a doubtful situation.

In particular, such an interpretation allows using the pattern of inquiry itself as an analytical lens for the empirical study of situated actions in the evolution of wicked situations. Secondly, it can be used as a heuristic advice (in the sense of a 'good practice'), providing a pattern for systemizing actions to people in such a situation.

In Stevens et al. (2008), the first option was chosen; the patterns of inquiry were used as analytical lens to categorize the actions of a computer user reacting to a critical incident. The analysis uses the technique of Sequence Analysis (Wernet, 2009) in order to reconstruct the further development of the situation, based on the interaction between users and (computational) environments in sequential progression.[63]

[63] Sequence Analysis is a part of the Objective Hermeneutic. Like Conversation Analysis, and Ethnomethodology respectively, the Objective Hermeneutic refers to the sequential orderliness of human social practices. However, under this common umbrella it seems that a crucial distinction between both is the different empha-

This analysis follows the sequential progression in the reflection on the artifact present-at-hand. It shows that in this case, the action follows a structure similar to the patterns of inquiry outlined by Dewey (1938).

Chapter 5 presents the concept of Appropriation Infrastructure which supports End User Development in the moment when the artifact become present-at-hand, thus constituting a wicked situation. The model of Dewey (1938) indicates that supporting users as reflective practitioners should provide the means to:

1. Explore the history of socio-material traces that reach awareness in the situation, in order to support the determination of problems and problem-solutions (stages 1-3), and
2. explore futures of socio-material traces that reach awareness in the situation, in order to support the solutions, and to test problems hypothetically and in practice (stages 4-5).

Moreover, the situated actions should be perceived as moments in the evolution of socio-technical traces, and therefore, as products of development traces as well as producers of such traces. The design of an Appropriation Infrastructure should take this twofold character into account.

4.3 Social quality of artifacts as boundary objects

> "End-users, as owners of problems, bring special perspectives to collaborative design activities that are of special importance for the framing of problems. The "symmetry of ignorance" requires creating spaces and places that serve as boundary objects where different cultures can meet. Boundary objects serve as externalizations that capture distinct domains of human knowledge, and they have the potential to lead to an increase in socially shared cognition and practices (Resnick et al., 1991)" (Fischer, 1999).

In this section, I explore from the phenomenological perspective outlined above the genesis of the artifact as a social boundary object in the sense of Fischer (1999). In particular, I elaborate the argument that the expressive quality provides a seed for a social boundary.

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sis assigned to the evolution of practices. The primary research interest of the Conversation Analysis seems to be the question of how situated action is sequentially organized by universal rules, while the primary research interest of the Objective Hermeneutic is the sequentially organized evolution of life praxis (Lebenspraxis). Hence, the Sequence Analysis makes use of a genetic version of sequential orderliness that can be labeled as the principle of sequential progression. The Objective Hermeneutic seems to be a more appropriate methodology for research on technology appropriation.

For this purpose, I turn towards the reflection on the situation in which the artifact becomes present-at-hand, and study in more detail the transition from the artifact as mediator between me and the world to a mediator between me and someone else.

In this moment, when the artifact present-at-hand reaches conscious awareness, the unity of the world is replaced by constituting subject and object as own entities. In that moment the contingent constructedness reaches awareness, so that we can - metaphorically speaking - play with the pieces of the artifact construction. Following the game metaphor, the pieces can structurally characterize that on one side they are elements of the present game, but they refer to a reality that exists outside the present game.

This picture makes use of the concept of the play of aesthetic perception as introduced by Kant and implicit to contemporary aesthetic concepts in philosophy (Seel, 2005) and the humanities (Pilz, 2007) (see also Section 1.4.3). In the case of playful games of reasoning, the sign's critical function stands in an inverse relation to the practical or instrumental functions. The unknown object is not subsumed by the known concept, instead, the known concept points negatively to the object as an unknown one.

In describing the inversion of identification, we use the concept of non-identical as it is introduced by Adorno in his aesthetic theory. In particular, Thyen (1989) has suggested that in Adorno's work one should distinguish between the "identification with" (where the particular object is replaced by the general concept) and "identification as" (where the particular object is pointed out by the general concept), which provides a conception similar to the inversion of the sign-function. If we look at the function of signs with respect to their capacity of connecting unknown objects and known concepts, an affinity between appropriation, abduction and aesthetic perception arises. In practical action, its function is to subsume the former under the latter (in this case, the intension and extension of a concept will collapse). In this sense, we can also say that the aesthetic perception is accompanied by an inversion of the function of identification (see also Section 1.4.3).[64]

The competency to identify something as non-identical describes in a logical manner the anthropological competency as man abandons the nexus of immediateness as discussed in Chapter 3. In particular, both topics are closely related to the moment of becoming aware of the artifact's artificial character and - related to this – the contingencies in its construction.

In the case where the artifact appears as a boundary object in a wicked situation, the artifact is detected from, but not be subordinated under the own perspective. In such a case,

[64] However, a systematic elaboration of the similarities and differences between Peirce and Adorno is beyond the scope of this work.

the existence of a perspective of one's own allows the negative identification of the object. The artifact appears as non-identical, and in this moment the artifact in its appearing refers to a foreign perspective, which raises three corresponding questions:

a) what are the foreign perspectives, and
b) how will the object look from each perspective, and
c) how are the different perspectives and the corresponding objects related to another?

Although these questions can be studied independently from each other, all are connected in their reference to the philosophical puzzle of sameness discussed by Frege (1892 reprint 1997). Frege's studies of the semantics of propositions in the form of 'a=b' illustrate his considerations, using the example of morning and evening star. In contrast to Frege, our primary interest is not the semantics of a sameness given by the proposition 'a=b', but the dynamical perspective of knowledge development. Thus I am interested in the construction of sameness in relation to the mediation of different perspectives.[65]

In a first step, we can take a look at the role of 'a=b' as a proposition in the context of knowledge development. Here, we can roughly distinguish between two cases. The first case describes the progress of knowledge which is explicated by a judgment that concludes 'a=b'. The second case describes a progress of knowledge which is made by judgments that make use of the proposition 'a=b' as a premise.

The main difference is, that in the case where "morning star = evening star" presents a progress of knowledge, the reasoning situation must provide enough evidence for the conclusion. In contrast, if the proposition is used as premise, we just believe it, and must believe it to be backed by empirical evidence.

An appropriate reasoning situation to attain the proposition as a conclusion might look like that: we see a star which appears in the evening, and notice that it looks like the morning star. Based on this comparative observation referring to both concepts (morning and evening star), we can identify the referenced objects as being the same. The appearance will be identified from the perspective of the two different concepts of morning and evening star with awareness that the referenced object is the same. From the present situation, the relation between both concepts can be conducted as a general cognition.

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[65] Star (1990) remarks that the boundary object conception is closely related to the problem of constructing and transforming identity, but makes only an indirect reference to Peirce. A comparison between a Peircean triadic logic focusing on knowledge development, and Frege's dyadic logic focusing on the semantic of knowledge is given by Müller (1999).

The appearance of the star thereby serves to be identified as several things at once, namely the evening and the morning star. So we can characterize the whole situation of the appearance of the star as a situated boundary object that leaves an epistemic trace. This issue becomes more evident if we study the situated boundary objects from Mead's conception of the *emergent event*.

The structure of the emergent event is related to the philosophical puzzle of emergence, which is for Mead related to question about the structure of the present. In the context of a phenomenological deduction of the present ,Mead (2002) states:

> "[A] reality that transcends the present must exhibit itself in the present. […] It is that there is and always will be a necessary relation of the past and the present but that the present in which the emergent appears accepts that which is novel as an essential part of the universe, and from that standpoint rewrites its past" (p. 42).

The role of emergent events as Farrell (1947) pointed out is the same as the role of the situated boundary object in the appropriation of a wicked situation:

> "[The] emergent event is in two systems at the same time. It is in the system of the past out of which it has emerged, and it is in the new system into which it be placed, and which will in turn become a reconstructed past with the passage of time" (p. 180).

The whole situation of reasoning therefore becomes a situated boundary object, because the appearance of the morning star in the evening transcends the present, yet exhibits itself in the present. This means for reasoning situations, appearance happens in two systems at the same time, namely when the morning star and the evening star are considered to be two different entities. In reasoning, a new system is created. Within this new system, it can be reconstructed that both stars are identical.

In his philosophy of the present, Mead (2002, chap. 3) connects the concept of emergent situations with the concept of sociality by stating that "[s]ociality is the capacity for being several things at once" (Mead, 2002, p. 3). A special case for a social object is the self, where Mead (1983) demonstrates that it is constituted by the dialectic of self-perception and interpersonal perception.

By studying the construction of identity using the idea of perspectival takeover, the argumentational move of Mead is highly relevant to our effort to work out the relation between the situated or expressive and the social boundary object, because it allows us to connect the logical, the phenomenological and the sociological perspective of identity construction via the concept of emergent events.

From a logical point of view, we can say that the conditions for the possibility of emergent events are given by the reasoning capacity to identify ‘a’ and ‘b’ in different reference systems and to conclude the identity of “a=b”.

We can apply this consideration to the special case, where the identified object is connected with the concept of the self (which leads structurally to a Meadean conception of the ‘me’ as a social product). The conception can be illustrated by a reasoning situation where someone stands in front of a mirror, noticing at the same time “this is me” and “this not-is me”[66] , and comes to the conclusion that the person is me from a foreign perspective. Here, the inversion of identification is a constitutive element in such emergent reasoning situations, where ‘me’ has the dialectic role to identify an object as identical as well as non-identical at the same time.

In his work on the ‘self’ as a dialectic unity of ‘I’ and ‘me’, Mead (1983) draws the consequences that the self has the capacity of being several things at once, and that there is a human capacity to reflect on the self from the perspective of a different reference system, and put this into relation to the own perspectives by means of inversion of identification.

Following Joas as well as Oevermann’s interpretation of Mead’s dialectic, one should not misinterpret the ‘I’ as a given, pre-social construction of the self. Instead, the ‘I’ should be perceived logically as the here-and-now introduced in Section 1.4.3, ontologically as the irreducible source of non-anticipatable spontaneity, which can surprise the actor as much as their environment. The ‚I’ is the irreducible positionality of a concrete life form. It presents a centeredness which constitutes a perspective on the environment . In other words, the ‘I’ can be interpreted as a center of the asymmetric, topological space described in Section.4.2.1, which can also be a source for the space’s evolution.

The consequence of such a conception is that primarily the ‘me’ is not only the outcome of the negotiation of self-perception with the interpersonal perception, but first of all an outcome of the constitution of the concept of self- and interpersonal perception.

The example of the morning star illustrates the case of an emergent event where the sameness of two concepts was generalized from a situation where two separated meaning construction come together through a common reference object. In asking for the constitution of ‘me’, one is confronted with an inverse case, where in the emergent event a non-identical me appears. In this situation, self-perception and other-perception can be ab-

[66] The expression of ‘X not-is P’ should emphasize that in our logical considerations we do not focus on the propositional content ‘not (X is P)’, but on the act of making a reference to an identificable object in its foreignness.

ducted as separated concepts. Moreover, without such abduction the object could not be identified as non-identical. This means that the emergent event is constituted as a contradictory unity of the appearance of a non-identical me, which refers to the concept of self-perception and foreign-perception. The specific character of the situation is generalized (or more precisely, sublated) in the concept of identification from the perspective of a generalized other. This identification from the perspective of the generalized other is a Hegelian sublation of a non-identical experience in the following sense:

1. the object ME is identified from the perspective PERS (abbr. PERS -> ME),
2. the perspective of generalized other PERS' is identified from ME (ME -> PERS'),
3. the object ME' is identified from perspective P'. Identifying ME and ME' as the same object constitute a sphere of negotiation mediated by the perspective of the generalized other (abbr.: PERS -> ME=ME' <- PERS').

Mead's dialectical conception of society provides a sophisticated conceptual framework for studying the relationship between self and society. Although my primary research object is not the self, but the artifact, I argue that Mead's conceptual framework also applies for the case of the artifact as a social object.[67] In particular, there is a close connection with the concept of boundary objects as it is used in this work. For example, the characterization of the ‚me' as Hegelian sublation mentioned above demonstrates that the 'me' is localized in the boundary area of the subject and his or her (social) environment. In other words, the 'me' satisfies the spatial feature of a boundary object. A further examination would also demonstrate that it satisfies the other formal characteristics of a boundary object as set out on page 100. This demonstrates the underlying affinity connection between the social constitution of the self (which is the focus of Mead's work) and the social constitution of artifacts (which is the focus of this work). In particular, further elaboration is to some extent a logical consequence of putting the boundary object into the context of a socialization theory and studying the conditions for becoming a competent member of a community of practice, although this topic cannot be worked out in greater detail here.

Mead's conceptual frameworks therefore provides an analytical vantage point from which we can study the role of the generalized other in the case of the artifact serving as a social boundary object that mediates between different perspectives. Moreover, the social boundary object is connected with the expressive one via Mead's concept of the generalized

[67] The issue is not so surprising if we consider that the constitutive structure of technology depends on the constitutive structure of agency as demonstrate in Section 1.3.

other, in the sense that the social grows out of the expressive quality in a qualitative transition during the progressive evolution.

At this point, my analytical concept stands inverse to Fischer's knowledge-oriented view on boundary objects (see also Section 1.4). In particular, this might clarify the constitution-theoretical relations: although the social and the expressive quality present irreducible elements of boundary objects, they are in an asymmetric relation to one another. While the social nature refers to the expressive nature, the other case does not hold.

Mead philosophy of perspectives based on the I/me as the paradigmatic example, which I have illustrated above on the example of the mirror-image. In order to demonstrate that this philosophy of perspectives can be applied to our problem of connecting expressive and social boundary objects I use an analogues example. The analogue example is given by a reasoning situation where an expressive boundary object appears in a crisis, leading to an identification of "this is a hammer" and the inverted identification of "this not-is a hammer". This reasoning situation is analogue to the mirror example, as in the essential point both are equivalent, namely that the referenced object has the capacity to be several things at once. In the case of the mirror, it was the mirror image. In this case it is the artifact present-at-hand that is a hammer as well as not a hammer. This expresses the social character of the artifact present-at-hand in a fundamental way, since the capacity to be several things at once is the essential feature of sociality.

In respect to the topic of identification, the relation between routinized and crisis situation can be characterized as follows: In routinized situations, our practical handling of objects has a subsumptive "identification with" attitude, where the particular, concrete object is subsumed under- or more precisely, replaced by - a general, known concept. However, in a crisis situation it comes to an inversion of this identification attitude, accompanied by a transition from the ready-to-hand to the present-at-hand.

Identifying the appearance as a non-identical object, we turn to look at the particularity of the artifact. In doing so, it will be connected with - but not replaced by - a general concept. The situation presents an alienation of the familiar which allows reflection on the relation of object and concept. In particular, the appearance of different perspectives allows to play with the object from different perspectives, so that the artifact becomes an expressive boundary object, which presents the *alter* for the *ego* in the play of perspectives.

The alienation from familiar identification marks an important step in the shift from the expressive boundary object to the social boundary object, since the foreign appears in play

with the identification of the artifact. This allows one to abstract the foreign perspective from this playful perception of an object to form the concept of the generalized other.
The emergence of this concept allows to taking the role of others and in doing so to perceive the artifact from a different perspective, or at least anticipate it being perceived differently from another perspective. By becoming aware of the generalized other as an own concept, it provides the fundamental aspects of the artifact as an object of a social practice, namely that first of all an object is relative to a specific reference practice (abbreviated: refpr –> obj) and second, that the identified object has a reality independently from one's own specific reference practice. The appearance of an alienated object is therefore constitutive for becoming aware that two different objects (obj_1 and obj_2) can be perceived as the same from different perspectives (abbreviated: ($pres_1$->obj_1 = obj_2<- $pres_2$)).

These brief analytical considerations provide the required theoretical fundament to complement the characterization of social boundary objects from an external observer perspective with an internal and phenomenal perspective. Following Star, the core feature of the boundary object conception is to have objects that are plastic enough to adapt to local needs, yet robust enough to maintain a common identity across sites (cf. Star and Griesemer, 1989, Star, 1990). This feature can be identified with the mediation character of perspective interleaving in the following manner. From an external perspective, we might study the cooperation of two social worlds, where we know two reference practices so that we can state $refpr_1$ –> obj_1 and $refpr_2$ –> obj_2.In addition, we also know that $object_1$ and $object_2$ serve as identical reference points (or as commonly structured identities, which is from a constructivistic point of view more or less the same). Hence, we as external observer construct the argumentation chain: $refpr_1$ –> obj_1=obj_2 <– $refpr_2$. This allows to introduce the concept of boundary objects in hypostatizing the identity construction obj_1=obj_2. This chain of perspective interleaving and abstracting can be expressed by the following notion:

EXT-SBO: $refpr_1$ –> obj_1–> boundary object <– obj_2 <– $refpr_2$

With the introduction of this concept we can now point out that the cooperation between the two social worlds is mediated by the type of boundary object I have defined above.
The perspective interleaving can be studied from an external observer position as well as from the internal actor position. In latter case, we will reconstruct from the interior perspective the reasoning chain in the flow of the actual situation. In the following study, the topic is considered from this perspective in order to figure out how social quality can be grown from expressive quality.

In order to raise awareness to the problems we are confronted with in such a qualitative transition, the examination starts with a reflection on Fischer's (1999) phrase that "[b]oundary objects serve as externalizations that capture distinct domains of human knowledge" (Fischer, 1999). The reflection should demonstrate that this function of serving as externalization is a derived one, which makes implicit use of the expressive nature of the boundary object.

The first topic that arises in the reflection is whether the distinct domains of human knowledge Fischer mentions also mean different reference practices. If this was true, it would not be clear how the externalizations of one reference system can be related to the externalizations of another, distinct reference system.

One way to tackle this difficulty is to argue that both externalizations are rooted in shared reference practices. However, such an assumption is insofar disappointing as boundary objects are motivated by a lack of a shared reference practices.

Another way to interpret externalization is to say that different objects have identical extensions (or references), but not necessarily identical intentions (or senses). Such an interpretation of Fischer's boundary object conception comes quite close to the conception outlined here, as we hope to demonstrate by this reflection.

In particular, the function of the boundary object to serve as an externalization of knowledge across distinct domains is founded in the possibility to appropriate boundary objects as non-identical entities, which itself is founded in the expressive nature of boundary objects as based on our competencies to live in a meaningful world. However, in a wicked situation we can reflect on the contingency of such a meaning construction. This means that the social nature is grounded in the expressive nature, although it cannot be reduced to it. Intention and extension are connected in the boundary object by means of its expressive nature. This posits different perspectives as a potential; yet only through its social nature the potential reaches actuality.

From the interior perspective, the appropriation of the social nature on the basis of the expressive nature can be schematically described as follows:

$$\frac{\text{refpr}_{ME} \text{ –> obj}_{ME} \text{ -> non-obj}_{ME} \text{ ~> } (obj_{OTHER} \text{~refpr}_{OTHER})}{\text{pr}_{ME} \approx \text{pr}_{OTHER}}$$

The first aspect "refpr_{ME} –> obj_{ME} ~> non-obj_{ME} ~> $(obj_{OTHER}\text{~refpr}_{OTHER})$" describes the development of the artifact from the perspective of the generalized other. Here, the organic reference practice of the 'I' enables to identify the object as a familiar artifact (refpr_{ME} –>

obj_{ME}), while the inversion of identification serves to highlight the appearance as non-identical with the familiar artifact (obj_{ME} ~> non-obj_{ME}). From this reasoning situation, we can prescind from the non-identical object that it will be identical to an object which belongs to a different practice (non-obj_{ME} ~> *(*obj_{OTHER}~$refpr_{OTHER}$)).

While the first aspect describes the anticipated sameness of an object of another practice, the second aspect "pr_{ME}≈ pr_{OTHER}" describes the identified obj_{ME} and obj_{OTHER} to be projected on a common object in a shared practice pr_{ME} ≈ pr_{OTHER} between ME and OTHER so as to serve as a boundary object between both worlds.

If these propositions are given, several relations can be set as identical, so that the artifact can be perceived as a common object, determined by the own perspective of ME and the (anticipated) perspective of OTHER. Thus, we can schematically describe a phenomenologically given boundary object as follows:

INT-SBO: $refpr_{ME}$ –> obj_{ME} –> common object of pr_{ME} ≈ pr_{OTHER} <~ obj_{OTHER} <~ $refpr_{OTHER}$

At a first glance, the schematic description (INT-SBO) looks like (EXT-SBO), which describes the determination of boundary objects from the perspective of an external observer. The reason for this similarity is that an external observer is also confronted with the identical problem. She must make a reference to something, to study the identified object from the perspective of the observed social worlds in order to identify the connections between the different objects in each social system. In addition, in both cases we must believe that our reference practices express a truth.

The main difference between INT-SBO and EXT-SBO is that the external observer takes the phenomenological construction of the boundary object for granted, but focuses on the cooperation between the social systems, and on how they are mediated by the different use of same objects. The strength of such a conception is that it can study the coordination processes without the introduction of a central instance, while the strength of the phenomenological conception is to present a theoretical model for the transition of an expressive to a social boundary object.

In this respect, both conceptions of the social boundary object are complementary to each other. The advantage of the interior perspective is to introduce an ethnomethodological stance on the research topic. In particular, the outlined phenomenological model follows the inner logic of the flow of action in socializing artifacts and making use of them as boundary objects of an (anticipated) shared practice.

With Mead, we have the necessary material at hand to connect the expressive with the social boundary object.[68] Both conceptions are linked through the appearance of the generalized other creating sociality, which presents the main part of the structural skeleton of the social boundary object presented above. Metaphorically speaking, the qualitative transition in the emergence of the sociality can be characterized like this: The expressive situation creates a place where we can play with the contingent constructedness of the dialectic artifact, perceiving the object from different perspectives. This allows one to see the object with other eyes; in hypostatizing these eyes, one creates a (new) place where we can then continue playing the game with somebody else.

The following elaborates the qualitative transition of the boundary object as it is perceived from the perspective of the generalized other. In this transition, the recognition of the artifact as social boundary object constitutes a common object in the social practice of self and other. This has first of all an effect on the construction of the artifact as it appears in its role as common object in a particular social practice. Secondly, this also has an effect on the social construction of self (given in Mead's concept of the 'me'), as it also appears in its role of being a shared practice. For example, it might be the case that a shared practice is mediated by the social boundary object, where one self appears in the role of user. In order to act appropriately in the mediated social practice, it might be crucial to take over the user role. Here, this means foremost to identify 'me' from the perspective of the user role. At this point, once again the close connection to Mead becomes obvious. Mead, in his consideration on the 'I'-'me' dialectic, has identified self-determination as not independent from external determination, but as needing to be integrated into the internal perception of the 'me', the 'own' and the 'foreign' perspective. To manage and integrate this manifold of identities is one of the main efforts of the self.

The underlying argumentative structure of this conception can also be applied to the artifact as it appeared as social boundary object, and to the mediated social practices of which different roles and participants are part. Here, the own role in an emerging practice is given by self-attribution, but at the same time it is also influenced by the perception of the other participant in the mediated social practice. Immediately following the appearance of the situation, foreign roles and corresponding role-taking are based on a generalized other. The es-

[68] Zehentreiter (2006) characterizes the work of Mead as *Romantic Pragmatism*. Therefore it might be no coincidence that we found in Mead a link between the expressive boundary object (which is influenced by Romantic understanding of expressiveness) and the conception of the social boundary object (which is influenced by the Symbolic Interactionism of Star).

sential point is that artifacts as social boundary objects mediate social practices with corresponding roles, which accumulate an anticipation of the behavior of external persons. In this mediation process, a dialectic moment of self- and foreign-attribution occurs, where the roles of both elements must be set in relation to each other.

Mead's conception of role taking prevents a location of the role of users and designers on a conceptual level[69] without denying such roles on the empirical level. Instead of postulating fixed roles, the suggested conception here simply assumes in an ethnomethodological manner the existence of roles and role taking as constitutive element of social practices, and that the negotiating and taking of roles must be made accountable to others. This has the methodological advantage that concrete roles need not be a-priori givens, but can be empirically identified by the reconstruction-logical sequence analysis of the progressive evolution of the boundary object. In addition, this theoretic conception helps capturing the evolution of roles which can accompany the progressive evolution of a situation.

Methodologically, such a reconstructive analysis makes use of the counter-factual assumption that the analyzed empirical material is the product of competent members, and authentic anticipation of corresponding social practices. In addition, the reconstructive analysis assumes that the *once* is sequentially ordered (see also Section 1.4.3) so that evolution of a crisis situation is directed towards progress in the achievement of the goal of overcoming the crisis.

In particular, a commutative reflection on a crisis situation that is directed towards crisis solution makes a general claim of rationality which transcends one's own perspective, but nevertheless expresses the specific quality of a wicked situation. Therefore the counter-factual assumption has not only a methodological significance, but also offers a norm in praxis which is applied e.g. in communication between actors of a social practice that is mediated by the artifact in question.

An example of commutative reflection in reaction to a crisis is presented in Stevens et al. (2008). The analyzed empirical material was produced in a thinking aloud session, using the software application. It describes a reflective interaction with the artifact in reaction to a breakdown situation.

[U = User, T1, T2, T3 = anwesende Usability-Tester]	**[U = User, T1, T2, T3 = present Usability-probands]**
T1: (…)"Haben Sie vielleicht äh ein Dokument, das Sie gerade mal hochladen möchten?"	T1: "(…) Do you have maybe uh a document that you just want to upload"?

[69] In my opinion, this is one drawback of the boundary object conception as outlined in Fischer (1999).

U: „Ja das Hochladen, dann gehen wir aber vielleicht wo anders rein. (1.0sec - klickt) so (lautes Saugen an den Lippen) (7.0sec - klickt) Na komm. (5.0sec - klickt) Ja, jetzt wäre die Frage, jetzt bin ich hier im Navigator (T2: mmhm), und wenn ich den Inhalt jetzt da drüben sehen wollte, ne (T2: mmhm) ganz einfach, Also dann, vielleicht (klickt) weiß ich nicht, vielleicht kann man das da reinschieben. Da geht irgendwas nicht." (T2: „em hmm") Nee, so! O.k., prima, kriege ich jetzt nicht hin. Ich hatte jetzt nur gedacht, vielleicht könnte man - sozusagen wie im Windows Explorer … so wie ich mir das vorstelle, scheint das nicht zu gehen aber das ist egal, macht nix."

U: "Yes the uploading, but then we should take another way in (1.0sec) (clicking) so (loud sucking on the lips) (7.0sec) (clicking) go on. (5.0sec) (clicking) yes, now it is the question, here I am in the Navigator //T2: mhm//, and if I would like to see the content over there now, no //T2: mhm// quite simple, then, perhaps (clicking) I do not know, maybe you can push it over there. Something is not working. //T2: em hmm// no, so! O.k, fine, I can't make it now. I had only thought , perhaps one could- so to speak, like in the Windows Explorer … in the way I imagined , it seems not to work, but never mind , this doesn't matter ."

Original transcript from an interview with a PaDU user

Author's translation of the transcript

The transcript presents a protocol of the flow of the wicked situation, where the artifact becomes present-at-hand, mediating material and meaningful constructed reality in the form of a contradiction. Moreover, the extensive explication sequence analysis (cf. Stevens et al., 2008) reveals that the reflected action of the user in the flow of the situation follows the above mentioned Dewey pattern of inquiry (cf. Figure 8).

Unfortunately, the protocol does not capture the qualitative transition of a wicked situation where the artifact present-at-hand appears as a as a social boundary object. Therefore I present in the following two additional protocols to illustrate how the social quality of boundary objects manifests itself in empirical material.

The first example elaborates the quotation of the PaDU user cited on page 13. This means the protocol is taken from an interview with a user using the feedback function of a software application to communicate design defects. Studying the transcript in a sequential manner should reconstruct how social practices are mediated by artifacts, and how the boundary object shapes and is shaped by taking on anticipated roles. The framing of the transcript is given through a feature in the Groupware-system BSCWeasel, called PaDU. PaDU allows BSCWeasel users to send design suggestions directly from their use context to a publicly available issue-tracking system, which is used by BSCWeasel designers (see Chapter 6). The User-Interface of the PaDU-Systems is based on a dialogue between the Remote Critical Incident Reporting. One active user of the PaDU functionality is an Information Systems student. The transcript is taken from an interview where he was asked about his experiences with the PaDU system.

Interviewer: Oder nehmen wir mal ein konkretes Beispiel, hattest Du schon gedacht ja das könnte man ändern oder das wäre toll äähm wo denkst da ist diese Idee auszudrücken da ist PaDu eigentlich ein schlechtes äh Vehikel? 00:27:39

Interviewee: äh, also ... ja also .. wo ich halt PaDU .. ich benutz PaDU dann eher auf generalisierter Ebene, wo ich halt denke dieser Hinweis ist wenn für alle wichtig .. also nicht das ich halt sage ich hab individuell meine Software angepasst oder solche Sachen, weil man z.B. im Weasel auch viele Möglichkeiten hat die Software individuell, eigene Sichtweise, eigene Gestaltungs äh Möglichkeiten hat, ne das man die Fenster anpasst und solche Sachen. Und ich würde PaDU nicht nutzen, um halt zu sagen ehh benutzt jetzt mein Skin wie du jetzt halt so gerade ne oder nä ich hab oder ehm mach doch in der ... in der allgemeinen Form das und das raus und das und das rein, weil das kann auch viele andere betreffen. Also wenn ich der Meinung bin, dass das nur die Allgemeinheit oder was he.. für die Allgemeinheit interessant ist und die Gestaltung für die Allgemeinheit interessant ist würde ich es halt nutzen, wie halt z.B. einmal eingefügt habe, dass da immer so eine leere Box war, so ne ausgegraute Box in BSCWeasel, die ich gerne weggehabt hätte was aber technisch glaube ich nicht ganz so einfach war [...] ja solche allgemeinen Gestaltungshinweise dafür würde ich PaDU benutzen, ehm im speziellen halt um meine ingenieuralisierte (???) sichtweise auf ein Programm se? äh wiederzugeben, würde ich PaDU nicht wirklich nutzen also da würde ich eher ehm vielleicht dann in äh in hin ner gewisser Hinsicht 'ne anderes Forum oder Medium nutzen dann, weil da wird ja mich nicht, weil PaDU ist ja von mir aus wenn ich so die Benutzeroberfläche sehe immer nur ne äh was stört mich in der Bearbeitung oder was behindert mich in der Bearbeitung äh meines meines Falles. das ist ja auch so als äh und als wie störend wird das empfunden und solche Sachen, deswegen ist es von daher so aus als ob ich halt wirklich nur ne also dann halt Fehler oder halt Anmerkungen die negativ laufen da abgebe in Padu.

Original transcript from an interview with a PaDU user

Interviewer: Could you give me a concrete example of when you thought something could be changed or improved, a situation where you thought PaDU isn't such a good vehicle for expressing this particular idea right now?

Interviewee: uh, so ... So yes .. when I used PaDU .. Well, I use PaDU on a general level, when I think my observation might be important for all. I wouldn't report how I've individually adapted my software or anything like that, there's for instance all these possibilities in Weasel for individualizing, being creative myself with how I adjust the windows and so on. Now I wouldn't use PaDU to tell people about that, to say, hey why don't you use my skin, I'd only do that in a general form, suggest taking this out, putting this in, when it affects many people. Once I think this is for the general public, an aspect of design that's interesting for all, then I would use it. For instance, I've entered once that there's always this empty box, some ancient box in BSCWeasel that I'd like to get rid of, but I think that wasn't easy from a technical point of view...[...] General design suggestions like that are what I'd use PaDU for. When it comes to more specific matters, passing on my own designing opinions about the program, that's not something I'd use PadDU for, that'd be for a different forum or medium. Looking at PaDU, from my user's point of view, I only see what gets in the way of my work, my focus. The question is how objectively can I evaluate how much of an interference the same problem is subjectively for other users, that's why I tend to only enter remarks about proper errors or malfunctions. .

Author's translation of the transcript

In the following, no extensive sequential analysis will be presented. Instead the interpretation is limited to illustrating some remarks. First of all, we see that by using the PaDU feedback system the artifact serves as an expressive boundary object mediating between an imagined design concept and a realized design object. But beyond the determination of the contingent construction of the artifact, the interviewee is also confronted with the problem of having to decide whether the imaging design concept is only of individual interest or of general interest for an anticipated user community.

Therefore, the transcript illustrates that using a feedback system like the PaDU system is not only a question of overcoming a problematic construction, but also one of identifying social practices that become present-at-hand in the actual situation and, from this perspective, to find out the anticipated role of oneself and of others in this practice. Moreover, the analysis demonstrates that the artifact presents a social boundary object, to which more roles are relevant than just that of user and designer. In particular for the use of the PaDU system, the role of the general public is crucial.

The transcript is therefore a good illustration of interior perspective on the progressive evolution of a boundary object manifesting itself in the material that is empirically accessible. In addition, it shows the advantage of a reconstruction-logical analysis which follows the inner logic of the flow of the wicked situation, instead of subsuming the case under pre-defined categories**.**

For example, the analysis makes one aware of the role of the general public in the user's participation in a public product community by articulating situated developments. However, in Fischer's (1999) considerations on the artifact as a boundary object, this important role of 'general public' is neglected. This means that an empirical study grounded in Meta-Design as a conceptual framework must either neglect this role, or subordinate it either to the designer or to the user. However, there are strong arguments why the role of the general public cannot be reduced to any particular interests (or the sum of particular interests) as represented by the role of the designer and the user. Therefore in both cases, Meta-Design does not provide an appropriate conceptual framework to capture the role that appears in the transcript, and fails to draw appropriate consequences for the design and the evaluation of an Appropriation Infrastructure.

The evolutionary perspective shows that the establishment of the social object is given by a quality transition in the expressive object. From a phenomenological perspective, the seminal point is that in this transition the artifact present-at-hand also mediates corresponding social practices and associated roles.

From the end of a successful transition, the mediation chain of INT-SBO from page 137 can be resolved for the above example as follows:

Weasel use_{ME}–>design $idea_{ME}$–>PaDU contribution<~design $idea_{GP}$ <~ Weasel use_{GP}

From this perspective, we can try to reconstruct a related situated development in its evolution. First, the artifact appears in the situation in such a way that it motivates a design remark (Weasel use_{ME}–>design $idea_{ME}$). In reaction to this, the PaDU feature must arise in the situated development as an option for action. Moreover, in this situation PaDU did not just present a feature, but itself mediates the social practices of a public BSCWeasel design discourse with its associated roles. In the concrete case, the role of a *general public* must have appeared. Taking over this role of a generalized other, the own design ideas could be explored as the perspective of an anticipated future. This means in our case, PaDU contributions were judged from perspective of the role of a general public that the user must have to be taken himself. This short example illustrates in which way the associated mediation processes of boundary objects can be reconstructed from participant's reflections, here from the reflections of a PaDU user.

The second protocol illustrates more clearly role constitution and taking as outcome of and force in the flow of a wicked situation. The protocol presents a contribution that was taken from the public issue tracking system. The contribution was produced with the help of the PaDU feature that was integrated in the application:

Beschreibung der Arbeitssituation:	**Description of the work situation:**
Umbenennen von Verzeichnissen und Dateien	Renaming of directories and files
Beschreibung des erwarteten Verhalten:	**Description of the expected behavior:**
Menuepunkt o.ae. Funktion, die das Umbenennen ermoeglicht, im Idealfall, aendern des Namens mit Mausklick	Menu item or similar feature, which allows the renaming, ideally, with a mouse click
Beschreibung des Critical Incident:	**Description of the Critical Incident:**
Funktion nicht vorhanden oder nicht gefunden, d.h. ich bin ein DAU ;-)	Function does not exist or is not found, i.e. I am a DAU ;-)
Bewertung:	**Review:**
3. Mittleres Problem. Ich konnte meine Arbeit erledigen, aber es hat zusätzlichen Aufwand erfordert.	3rd medium sized problem. I could do my job, but it required extra effort.
Original contribution	**Author's translation of the transcript**

This contribution documents a critical moment in the transition of a wicked situation from a personal problem to a problem that exists from the perspective of the generalized other as well. The crucial point here is the phrase „I'm a DAU ;-)" which is an ironizing self-attribution

of the DAU role. The term DAU (“Dümmster Anzunehmender User”) is a derived from the German abbreviation GAU (“Größter Anzunehmender Unfall”), but has also become popular as an English abbreviation that stands for dumbest assumable user. Normally, IT- or help desk- departments internally use it to characterize requests from computer users without any basic knowledge in the domain. Typically, a DAU- request describes a basic error in reasoning or using a computer application.

The ironizing phrase is therefore not just self-attribution, but also a self-justification which attempts to legitimate the contribution in the form of anticipated exculpation. The anticipated exculpation expresses a critical issue in the social quality of a wicked situation, where not merely the object’s role, but also the role of the subject is unsettled. At the same time, the mediated social practice enforces that both must be settled in some manner. This leads to a problem in the articulation of the wicked situation which must be solved by the subject. The concrete problem in the recorded situation is expressed by the phrase “function does not exist or is not found”. This indicates that during the actual stage of the recorded wicked situation, both options present modalities in a logical sense. In the moment of writing the PaDU entry, they must be part of the situated boundary object given by the artifact present-at-hand.

The ironizing phrase therefore refers to a critical moment in the transition of making the wicked situation a shared topic. One the one side, the actual stage of the wicked situation is given by fact that in both modalities ‘function does not exist’ and `function is not found’ are possible options for settling the wickedness. Unfortunately, the artifact present-at-hand mediates a social practice, where it is only legitimate to articulate wicked situations in where ‘function does not exist’ is just a modality, but a fact. The contributor therefore excused himself by stating that he did further inquiry into the wicked situation in a private setting before he made it a topic in a shared discourse. This protocol shows a critical moment in the transition of the artifact present-at-hand about to establish itself as a social boundary object. This example also shows the high degree of reflective effort which goes along with the articulation of a wicked situation, since the articulation makes it necessary to describe the situation in general terms that can be understood from an external perspective; in addition, one has to decide whether it is legitimate to make the wicked situation a shared topic or not. All this makes it necessary to define the mediated social practice in terms of the own and the others’ roles, and last but not least, also in terms of the role of the actual situation.

With respect to the outlined theoretical model, the two examples are highly illustrative, as they demonstrate how the establishment of the artifact as a social boundary object is ac-

companied by the interpretation of the social practice, and the roles which the different participants play in this game. In particular, the analysis demonstrate that not just a computer competence is needed to inquiry the problem, but also a social competence is needed to follow the rules of participating on the design discourse. From a methodological point of view, this very brief interpretation indicates how the theoretical model provides an analytical lens to empirically study the mediation of the artifact as social boundary object.

The theoretical model suggested here elaborates the boundary object quality of artifacts from an interior perspective on its appearance. However, the examples illustrate that such 'subjective' perspectives do not exclude the empirical study of the object by research. Moreover, with respect to Fischer's (1999) related conception, one advantage of the model presented here is that it makes fewer presumptions. In particular, it did not postulate on the theoretical level any specific roles and statements of how subjects take on and play these roles. Instead, the elaborated conception provides an analytical tool for access to the object of research which requires fewer presumptions on the theoretical level than models currently in existence.

This doesn't mean that the underlying theoretical concept has no presumptions, or that these presumptions did not shape the object of research. Therefore, we are well adviced to reflect on the issue of how the chosen theoretical and methodological conceptions shape the analysis as well as the selection of the analyzed data material. For example, in the case of analyzing contributions made in the public design system, one has to take into account that the data material represents expressions of a quite advanced inquiry into wicked situations, which combines inquiry into the nature of the emerging object with inquiry into the mediated social practices.

This means that the retrospective analysis only has direct access to the 'successful contributions', which are traced in the public issue tracking system, but not to 'stranded contributions'. Therefore, an empirical research that studies manifestations of social boundary objects, e.g. public design discourse, provides only indirect knowledge of stranded contributions that lead to the establishment of a social boundary object. The notions of 'successful contribution' and 'stranded contribution' do not express any value, but a retrospective characterization of the genesis of the tracked issues: an issue in the tracking system represents an incident that has a genesis. In particular, their existence marks an end of genesis, and the term successful should express the point that their genesis has successfully reached this end. Based on the assumption that the genesis is sublated in the actual state which comes into existence, one can start from the end of the genesis to figure out the different

stages which led to it. These stages can be used to characterize ‘stranded incidents’ as follows:

(i) their evolutionary process is comparable to the evolutionary process of ‘successful contribution’,

(ii) however, their evolution did not reach the final stage of ‘successful contribution’.

This short reflection is meant to alert to the dangers of succumbing to a pro-participation bias. Hence, one should reflect on strategies for obtaining better access to stranded incidents. However, based on the assumption that the result also protocols the process, we can capture pieces of indirect knowledge by reconstructing the evolution that has been inscribed in a ‘successful contribution‘. Such an analysis would provide a first picture of the existence and structure of the ‘stranded contribution’.

Studying the protocols from such a perspective, we can reconstruct for example from the phrase “Function does not exist or is not found, i.e. I am a DAU ;-)” that the user is not sure about writing a contribution because he thinks that the doubtful situation was perhaps triggered by his incorrect interpretation of the material object. This is an indirect hint at incidents which are stranded because the user could not identify whether the wicked situation fits the rules of public discourse. In a similar way, we can conclude from the interview transcript with the PaDU user that he would not make an entry in the system, if he considered his remark not to be of public interest.

Thus, in both cases a careful reading reveals that situations exist where the artifact becomes present-at-hand, yet does not become a boundary object between user and designer. In such cases, the user must handle the situation autonomously, or communicate his wicked situation in other forms than using the public communication platform of a product community.

In order to shed some light on stranded contributions which are not recorded in the public design discourse system, it is useful to re-interpret results from one other research paradigm in this area. The goal of the re-interpretation is to close gaps in our knowledge of the communicative appropriation of wicked situations. However, before making a reference to a result gained from another theoretic background, it is useful to explicate the different research perspectives and how they relate to each other.

As mentioned above, the theoretical conception of the social boundary object presented here, and that of Griesemer and Star are not contradictory, but complementary to one another. In a similar way, the reconstruction-logical analysis of the perception of social boundary objects can be further supplemented by empirical studies, which analyze from an exter-

nal perspective the role of artifacts in the designer-user communication as well as the strategies of users to deal with a breakdown situation. The nexus of both types of studies is the counter-factual assumption that action in reaction to a wicked situation makes a claim on a general rationality which transcends the own perspective on the situation. By transcending the own perspective and in making the wicked situation accountable,[70] a dialectic between an interior and an exterior perspective occurs similarly to the 'I'/'me' dialectic described by Mead.

This means that the description provided by an observer is for the actor a source for reflection on the interior perspective from an exterior point of view. Similarly, the actor's description provides a source for the observer to reflect on the exterior perspective from an interior point of view. In both cases one must rely on the counter-factual assumption that there is a match between both perspectives, based on the regulative idea of an objective description of the wicked situation. This means that both perspectives are not identical, but are connected through the regulative idea of an objective description, and connectable through the existence of boundary objects.

Having in mind that Fischer's boundary object is mainly constituted from a designer-centered perspective, his work on the artifact as a social boundary object provides a notable complementation to my work.

Also, Pipek's studies of user activities' during breakdowns of shared infrastructures provide important pieces with which to complement our picture of social boundary objects. In Pipek and Syrjänen's (2006) analysis, relevant factors appearing in a breakdown situation such as defects in the technology or conflict with work standards are described. Unfortunately, the authors do not make a clear distinction between the factors that appear as relevant in the breakdown situation, and the factors which lead to the breakdown situation. This may refer to the heuristic assumption that these factors are identical. The reason for this also lies in the regulative idea of an objective description, where the person concerned is interested in figuring out the relevant factors which lead to the breakdown situation, and at the same time needs to overcome the situation. Therefore, one can assume the factors figured out by the person concerned and those figured out by an external observer to be the same, because they are the correct and true factors.

Another highly interesting study that sheds more light on social practices reflecting on design issues in reaction to breakdown situations is the empirical study of Dörner et al. (2007).

[70] This also means to make the own action accountable because it is inevitable interwoven with the flow of the wicked situation (see the story of Oedipus).

In particular, they reconstruct the workflow of handling breakdown situations in organizations (cf. Dörner et al., 2007, pp. 790). The reconstruction follows the activities of the users as the owners of the problem. For this purpose, Dörner et al. conducted a set of interviews with employees who use ERP software, and studied several problem-solving strategies mentioned by the employees. They clustered the different persons involved in this process to define their respective roles. In addition, they use the organizational boundaries to further differentiate between internal and external roles. As relevant internal actors, they focus on colleagues, key users and the IT-department. The employees also mention producers, system houses or IT-consultants as relevant external actors, who appear in the workflow of dealing with a problem.

Like the reconstruction-logical analysis of the PaDU use described above, Dörner et al.'s (2007) empirical study demonstrates that the artifact serves as boundary object beyond designer and user collaboration. So, it becomes obvious that the Meta-design conception focuses only on a small section of the diversity of roles between which the artifact serves as a boundary object mediating between different social worlds. Meta-Design treats the entire discourse inside a client's organization which is mediated by the artifact as a black box, and do the same with discourses that involve additional external actors (although the newer work of Fischer indicates a leaning closer towards this possibility).

Without empirical work like that of Dörner et al.'s, one tends to subsume the diversity of actors inside the client's organization under the single category of users, while the diversity of actors outside the client's organization is subsumed under the single category of designers. So one of the merits of Dörner et al.'s work, or a carefully conducted reconstruction-logical analysis of wicked situations as outline above, is to point out the diversity of actors for which the artifact serves as a boundary object. Both kinds of studies provide evidence that situations exist where users reflect on the contingent artifact construction, but do not communicate this to the designers or a public user community.

This raises the question what other possible strategies users pursue to realize and communicate a further development in the construction of the artifact. From Dörner et al.'s (2007, pp. 790) study we can learn that colleagues, key users and other persons in the immediate social environment of the person concerned play an important role. However, with respect to the issue of how cooperation is shaped by the artifact as a social boundary object, Dörner et al. (2007, pp. 790) only give scarce information. In order to fill this gap, it makes sense to combine Dörner et al.'s study, which follows the logic of an external perspective,

with an interior, evolutionary perspective on social boundary object as elaborated in this work.

From the interior view, the establishment of a social boundary object is rooted in the progressive inquiry process in the flow of a wicked situation. Reflecting on the entire situation, the inquiry covers not only the artifact construction in question, but also the identification of the social practice, and its roles as shown in schematic characterization of INT-SBO on page 137. Furthermore, the progress is related to a complex, recursive process of role anticipation, role take-over and the determination of one's own role, as well as the role of the artifact in question from the newly assumed perspective.

This brief analysis of the use of the public issue tracking systems indicates that in such cases the determination of the artifact in question, and the processes of role assumption are quite sophisticated, and the anticipated legitimated participation comes with many prerequisites. In order to find a classification scheme for EUD-relevant social practices where design issues in a broad sense are articulated, it seems natural to elaborate the progress of differentiation of the social boundary object in the social practices which appear through the artifact in question. The goal of grounding the classification scheme in the progressive evolution of a wicked situation is to attain a distinguishing feature that stands between the social practices of articulating a 'successful contribution', and the social practices of a 'stranded contribution'.

In the literature, Oevermann has suggested to take the rules of legitimate discourse topics as distinguishing features of social practices. In the following, I will adopt his concept to specify a distinguishing feature.[71] This leads to a slightly different classification of social practices and roles from that of using organization membership as a distinguishing feature, as in the work of Dörner et al. (2007).

The 'legitimization rules'- criterion suggested here and the 'organization member'- criterion used by Dörner et al. are related to each other via the social proximity of participants in the social practice in question. In particular, the organizational boundaries provide a first and often good indicator of the social proximity of agents, and the criterion has the advantage that it can be easily judged from the perspective of an external observer. Therefore, the criterion is of great heuristic value, and it is often a good choice to classify social practices in empirical studies by an easily operationalizable criterion.

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[71] The motivation to adopt the rules of discourse legitimization arises in the analysis of PaDU use. In that analysis we have seen that the essential feature of deciding to share a wicked situation experience depends on whether the experience is an (anticipated) legitimate topic of the discourse.

However, for my analytical interest, the criterion has the disadvantage that it did not express the essential feature of the structure of the social practices where a 'stranded contribution' may be articulated. Therefore, Oevermann's criterion of diffuse and specific roles in social relations will be adopted as an alternative analytical tool kit. He uses this determination as a distinguishing feature separating community and society on the analytical level. While communities represent collectives of persons as a whole (families, friends, etc.), societies represent collectives of role representatives that have well-defined functions. The characteristic of diffuse social relations is that the burden of proof is carried by the person who wishes to *ex*clude something from being discussed in the joint discourse, whereas in the case of a specific social relation the burden of proof will be inversed. In this case, the burden of proof is carried by the person, who wants to *in*clude a topic in the joint discourse (e.g. in referring to a codified specification).

Applying this criterion of *in-* and *ex*clusion to the case of public design communities, we see some indicators that contributing design issues refer to a social practice that has a socializing tendency.

For example, in the case of PaDU as a public design discourse environment, we have seen in the interview above that the user feels an obligation to relate to a topic that is of general interest for the user community of BSCWeasel. This means that the social practice is interpreted as a socialized one, with a corresponding legitimatization rule that is given by the question whether the design issue is of general interest.

In the case of PaDU this was an anticipation that has been made by one of the users. However, we found a similar perception of the social practice also from a manufacturer's perspective. For example, Gulley (2006) describes the case of the company, MathWorks, which tries to help their user community to exchange user generated MATHLAB files. In contrast to exchanging MATHLAB files with co-workers or friends, in the case of exchanging MATHLAB files in public user communities the users need to be aware of the submission guidelines. Gulley (2006) discusses the question of whether the guidelines should provide a high and a low barrier for participation, because "[u]unfortunately, many of these files are […] poorly motivated (*homework problems are of no general interest*)."

This means that from a user as well as from a manufacturer's perspective, the participation in the public use discourse is latently confronted with the legitimization of the contribution, based on the question if something is of public interest or not.

In particular, he gives a hint of which design issues should not belong to a public design community, namely *homework problems* (although from an individual perspective, it might

be hard to decide if a homework problem captures just a particular or a general design issue). Although we do not have empirical evidence, it is plausible to expect that discussing homework problems with friends or colleagues would not follow the same rules of legitimization as given in public design communities.

The brief analysis also demonstrates that a remarkable feature of transition from a private conversation to a public discourse occurs when the mentioned philosophical puzzles of experiencability, communicability and generalizability are practically solved. In particular, the aspect of general interest refers to a new quality which appears in the artifact when it operates as a boundary object. With the introduction of the concept of the general public, the artifact connects in mediation to a public place, where the different interests involved with the design appear and are negotiated. Given that the negotiation of interests is traditionally attributed to the sphere of politics, it makes sense to speak here of the political quality of the artifact serving as a boundary object.

4.4 Political quality of artifacts as a boundary objects

The artifact is a common object that serves as a boundary object in communication. This specific political quality arises from the fact that the artifact is not only a common object in communication, but that the design of the object itself is a topic negotiated in communication. In recognizing the artifact as shared object, a shared interest in the form of the object also arises. However, these interests do not diminish the different perspectives on the object.

The formative arrangement of the social and political qualities of the artifact can be characterized as follows: The artifact is not only a medium, but the outcome of social practices as well. In becoming a common object, the artifact becomes the object of bargaining processes. This constitutes a political sphere where particular and general interests can be figured out and are negotiated.

This political sphere becomes apparent if one actor starts to further develop the artifact as part of a shared infrastructure. This causes a cooperative process, where different perspectives are negotiated in relation to the individual and common interests on the anticipated features. However, it is this cooperative process which creates a common ground to figure out what the general interest is and, in relation to this, what a particular interest is. This also means that mostly, different interests do not emerge until the negotiating process has started, when the articulation of own interests is related to an anticipated generality. This

means, own interests are only given against an anticipated generality, and only in their relative position against a common object.

In the previous section I have referred to Gulley's (2006) description of the problems of a manufacturer in managing a user community platform. In reaction to the work of Gulley (2006), I took a closer look at the platform. In particular, I found a paragraph in the submission guidelines of the MATHLAB User Community, which are posted by MathWorks. This paragraph states that any submission must *not directly compete with products offered by the MathWorks or its partners*.[72] With respect to the political quality of the artifact serving as a boundary object, this is of interest insofar as it presents an example of anticipation of a conflict of interests. In particular, it does not present a conflict in one, but in two dimensions. In the first dimension, it expresses a latent conflict between the manufacturer of MATHLAB and agents that use the platform to distribute competing products. In addition, it also expresses a role-conflict of MathWorks itself, because MathWorks obtains two roles: that of the provider of the user community and that of the producer of the MATHLAB product. In the role of the provider for the user community, MathWorks is obliged to serve the general interest of the user community, and from this perspective, the restriction of submissions is questionable. On the other hand, in its role as the producer and vendor of commercial products, MathWorks is obliged to market its products successfully, not to support the distribution of alternative solutions and the marketing of (direct) competitors.

In my own empirical studies on the user perception of the public design discourse environment integrated in BSCWeasel, I have found similar indicators, signaling the relevance of the political dimension as well as the importance of trust and the ambivalence of transparency. For example, sometimes users are afraid to publish design issues because others could *misinterpret* what they express within the public discourse environment, and are concerned about others forming a wrong image of them. At this point, too much transparency can be problematic. An excerpt from an email correspondence illustrates this problem. We received the following feature request by email. Based upon our design philosophy, we made this request public, notifying the user by an email: „I have put your suggestion into our issue tracking system." In reaction to this, we got a second, somewhat concerned email: „Could you please delete my request? I will write a new one where I will express more precisely what I want and try to prevent some conflicts with the [BSCW] developers. I heard they provide a "Server-to-Server"-transfer as a commercial service". The development of such a web service would have endangered the current business model of the

[72] Cf. http://www.mathworks.com/matlabcentral/ (8 Feb. 2009).

company licensing BSCW for commercial purposes. Obviously the user fears that the company could withdraw its support for the web service interface which BSCWeasel is based on, and did not want to run this risk. However the essential point is not whether the company really has a problem with the desired feature or not. Regarding the design of the Appropriation Infrastructure, the key issue is that the participation of the public user community comes along with a political dimension, where the user reflects on his problem from the perspective of an anticipated other.

Transparency and the power-relation between user and manufacturer also affect the motivation to take over the manufacturer's perspective and use available feedback mechanisms. In particular, none of the interview partners thought that users' feedback communicated via professional tools such as Microsoft's Crash Reporter for Office would really influence design. Based on the perceived asymmetry with regard to transparency of activities and power relations, users did not believe that a big company would care about an individual user. The importance of transparency was expressed in a comment on the design of discourse infrastructure integrated in the BSCWeasel: *"I like it that one sees what happens with a comment. If you write to Microsoft you do not have any idea what they do with it"*.

In interviews conducted with BSCWeasel users, we also ask about the strategies users apply to overcome a breakdown situation, and the role of colleagues, user communities as well as commercial software producers in providing the required information. All interviewees prefer to get support from their personal social network (if available). The role of the producers as well as a public user community were seen quite ambivalently. Some users trusted the producer with regard to the quality of the information provided and mistrusted information which was provided by an anonymous community. However, we also found the opposite opinion, e.g. in one user comment: *„I would trust the help texts from other users more. In particular, if this text would be written by someone being in a similar use context".*

In summary, we can conclude that different forms of social practice exist that become relevant when users reflect on design issues in reaction to wicked situations. Although I could not present a complete landscape of the different forms, the suggested classification scheme of communalized versus socialized practices provides a first analytical lens to study the different forms with.

In particular, it raises awareness that EUD research on user communities must take care not to subordinate two different issues under the same term of user community. The first issue addresses the support of collaboration in communities to which the user belongs; the

other topic addresses the support of the collaboration in a public user community. Since not every talk between friends is of general interest or should be made public, the two kinds of user communities are not identical. In consequence, the EUD research on user community should study both issues separately. Nevertheless, one should explore the connections and transitions between discourses in personal, private and public discourses. The next chapter describes how these issues can be taken into account in the general architecture of an Appropriation Infrastructure system.

5 Appropriation Infrastructures

In order to support situated development in the continuous evolution of software, this section interprets the conceptual framework elaborated above from a designer's perspective. Doing so, one has to be aware that a conceptual framework, developed for analytical purposes, should not be read as a direct blueprint for the architecture of a system for computer supported appropriation work. Yet the conceptual framework can sensitize to critical aspects which need to be taken into account during design conception.

Using the practice lens of the duality of technology (Orlikowski, 1992, Orlikowski, 2000), we can interpret the situated artifact in practice as a cut in the here-and-now of a distributed evolving of socio-material structure. In this picture, in-situ design describe a situated development where a reflective practitioner the influence the evolution in "confront[ing] the materials of nature as a force of nature" (Marx, 1992, p. 283).

The moment of reflection constitute a design situation that is given by an inner and an outer perspective. The outer perspective refers to the socio-material structure which cannot be subsumed to our own particular perspectives. It is the external environment that enables, but also constrains the design at the same time. Although the external environment structured and largely determines the situated development, from the inner perspective of agency, the situated development is relatively open, as it provides the freedom to realize our design intention as actual change in the socio-material structure.

A first implication for design is therefore to increase the evolvability of socio-material structure, which is to be prepared for further development of the material as well as for meaningful constructed reality. Approaches such as Component-based Tailorability (cf. Stiemerling, 2000, Stevens and Wulf, 2002) have been suggested in the literature to prepare a technical system for change in the material construction of the artifact. In order to prepare a social system for evolution with the artifact and its usage, we found in the literature conceptions like the promotion of a tailoring culture (cf. Kahler, 2001, Trigg and Bødker, 1994), and conceptions of promoting group coordinators that take care of the diffusion and adoption of changes (cf. Budweg et al., 2008).

In order to support emancipatory praxis the socio-material structure must be evolvable, however the increasing the evolvability is limited in different dimensions. First of all, one must take care of the twofold character of structure, being not just a constraint, but also a resource for design. Secondly, increasing evolvability did not answer the challenge what

kind of evolvability is needed to enable an emancipatory praxis (see also the critical remark on the techno-centric EUD ideal on page 64).

Another design challenge is given by the distributed nature of evolution, where a local development is affected by development traces that are produced by someone else. Last but not least, even if a socio-material structure is evolvable from an external point of vie, the users become aware of evolvability in appropriating the resources and constraints provided by the environment.

In summary, we can identify three topics in supporting the continuous development of software artifacts in the local context:

1. Increase the evolvability of socio-material structure given by the artifact in question.
2. Provide tools to change structure in the local context.
3. Provide an infrastructure to deal with the distributed nature of the evolving artifact.

Section 6.1 presents an example of how the first point can be addressed by developing tailorable software in an agile manner. In contrast, this chapter presents with the Appropriation Infrastructure a design concept which focuses on the other two points.

The key idea of the Appropriation Infrastructure is grounded in the artifact present-at-hand which constitutes an inner perspective on a particular development situation. The situation evolves in the reflective action, where the given socio-material structure is manipulated in an ongoing process of exploration and experimentation. This creates a development trace that is interwoven with other development traces, which also affects the evolution of the socio-material structure in question. As demonstrated in Chapter 4, the artifact serves in such a situation as a boundary object that mediates between the self and the present socio-material context as well as between the self and social practices that becomes relevant through the local development activities.

In order to translate this theoretical insight into a design concept, I show in next section the key concept to use the artifact present-at-hand as the centre of an in-situ design activity. Metaphorically spoken the design concept supports the direct manipulation of wicked situations in the situated development.

Taking the result of Chapter 4 into account, Section 5.2 presents a design concept that supports the social dimension of situated development that are confronted with the problem of fragmented experiences (see also Section 1.4.2). The goal of the design concept is to provide the broader context of the situated development, in particular enable the user to integrate other people apart from the subject of the concrete constellation of development traces. From a software-technical point of view, Section 5.3 addresses the challenge how to

integrate a distributed design context that can be interwoven into an actual use context. Section 5.4 gives a summary of the different design issues in terms of a software-architecture of a modular Appropriation Infrastructure.

5.1 Direct Manipulation of the artifact present-at-hand

The discussion of evolving software artifacts in Chapter 2 has demonstrated that local innovations can be supported, if the users have the appropriate tools in the local context to change the specific artifact in its meaningful and material construction. In Chapter 4, I have shown that the artifact present-at-hand serves as a boundary object in initial point of in-situ design activity. The challenge for the design of Appropriation Infrastructure is to translate the analytical result into a design concept that takes the demands of Chapter 2 into account. The design are based by the following design-metaphor: *In situated development the user act as a reflective practitioner (Schön, 1984) who thinks on the object (Peter, 2001) by means of directly manipulating.*

The design-metaphor guides the interpretation of analytical boundary object model in terms of the design-oriented conception of Direct Manipulation introduced by Shneiderman (1983).

The concept of Direct Manipulation describes the new character of graphical user interfaces (GUI) to support the 'natural' interaction with the object of interest. The central ideas around Direct Manipulation are the continuous visibility of the objects and actions of interest, leading to rapid, reversible, and incremental actions. Hutchins et al. (1986, p 317) pointed out that direct manipulation should create a user experience where the user has the qualitative feeling of direct engagement. The user interaction should feels like a direct manipulation of the objects of interest.

Bødker (1989) interprets the idea of direct manipulation from the understanding of Activity Theory, where computer applications are tools which mediate between the user and the material world:

> "The main idea is that a computer application, from the user's perspective, is not something that the user operates on but something that the user operates through on objects or subjects of interest in the work activity. In other words, human beings operate through computer applications, as well as other tools, on materials that they are turning into products with the help of others" (Bødker, 1989, p. 173).

This Activity Theory-oriented view provides a link between the idea of direct manipulation and the dialectic concept where the artifact serves as a boundary object between subject and material world. The similarities between the concept of Direct Manipulation' and the

elaborated dialectic concept of ‘artifact’ are given by the semiotic character of mediums: the inherent function of a user interface as a medium to represent the object of interest without presenting itself to conscious understanding. A good medium is therefore transparent, which is pressed by the term “direct”: The interaction with the object of interest in *indirect* as it is mediated by the artifact. At the same time the interaction is *direct* because the medium do not disturb the interaction as it becomes a part of the own body (see also Section 4.2).
In the case of direct manipulation, Hutchins et al. (1986, p 317) express this feature as follows:

> “The [artifact or tool serving as] interface should be unobtrusive, not interfering or intruding. If the interface itself is noticed, then it stands in a third-person relationship to the objects of interest, and detracts from the directness of the engagement” (Hutchins et al., 1986, p. 317).

In the work of Hutchins et al. (1986) as well as in the one of Norman (1986) ‚breakdown situations present a residual category which is not reflected in theory, and has to be prevented in practice. This was criticized by Bødker (1989, p. 174), and in opposite to the cognitive engineering conception of Norman and Hutchins, she refers to Activity Theory where breakdown situations play an essential role in human activity and human development.
She studies the direct manipulation from a breakdown perspective, where a shift in focus occurs: In routinized work, the artifact is a tool that serves as the mediating interface between user and the material the user is working on. One special feature of computer applications is that the object of interest is inside the computer artifact (cf. Bødker, 1989). In other words, the computer is at the same time work-tool as well as work-material. In the moment of breakdown, the mediating work-tool becomes the object of interest.

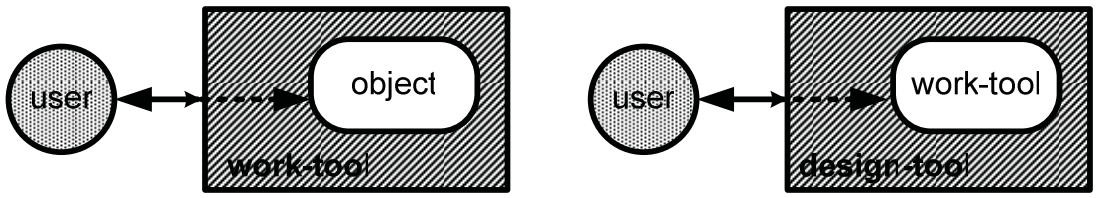

Figure 9 The object is present and handled only in the artifact. The solid arrow indicates physical interaction, the dotted arrow phenomenological interaction. Through the focus shift, the work-tool becomes the object of interest, while the computer system becomes a design-tool (figure adapted from Bødker, 1989, p. 181, fig. 1).

Figure 9 illustrates the shift in focus: At the beginning of a breakdown situation, the rectangle in Figure (a) and Figure (b) presents identical artifacts from a material point of view. However, there is a (temporary) change in the cognitive construction. Engeström comments on this issue, when he remarks that there is nothing in the material makeup which deter-

mines if something is an object or a tool; this question can only be answered in relation to a specific activity.

It is important to understand, that from the position of Activity Theory this question is *relative to the activity* and *not to the user*. The mental shift is related and embedded in the activity as a whole. Activity Theory argues from the special character of the subject-matter of activity, while the idea of expressive boundary objects can be interpreted as an application of the logical inquiry into the problems of mediation. Thus the homomorphism between both conceptions is not surprising, since human activity in its general form is a problem of mediation between humans and nature and between the levels of matter and meaning, respectively. So, structurally the role of activity in Activity Theory and the expressive boundary object elaborated in Section 4.2.1 have a similar function, namely filling the constitution-theoretical place that allows mediating the mutual determination of intentional and extensional object.

The link between the design concept of direct manipulation and the Activity Theory drawn by Susanne Bødker also presents a link between the idea of an expressive boundary object and its design implications. In particular, applied to the research subject, Bødker's interpretation helps to concretize the design implication of the idea to support practitioners who wish to reflect on the object. In the breakdown situation, the expressive boundary object is the work-tool in question as well as the mediating design-tool. The artifact serving as an expressive boundary object should provide operations that allow the direct reflection and manipulation of the object of interest.

In the case of direct manipulation, Hutchins et al. (1986, p. 314) have outlined some properties of computer systems which supports direct manipulation. In particular they argue that the system should:

1. represent the object of interest continuously,
2. represent the manipulation options directly in the context of the object of interest, in particular the system should prevent the recall of complex syntax,
3. and enable rapid incremental reversible operations whose impact on the object of interest is immediately visible.

As outlined in Section 4.2, the artifact appears in wicked situations as an expressive boundary object mediating between the user and the situation in question. In Bødker's terminology, we can describe this as a shift in the object of interest. In routinized work, we use the computer artifact as a tool to work on the work-material, whereas in a breakdown we shift focus from the work-material to the work-tool. In such a situation, there should be

means to represent an option for manipulating the work-tool in its immediate context. These options should allow for an incremental, reversible change of the work-tool.
This perspective on the direct manipulation of artifacts as an expressive boundary object in a breakdown situation provides a first guidance for the user centered design of the Appropriation Infrastructure.
From the perspective of human computer interaction, the Appropriation Infrastructure system should be interwoven in the use context of the artifact, so that in wicked situations the Appropriation Infrastructure system enables a direct reflection on the construction of the artifact present-at-hand, and therefore also, play with the underlying socio-technical material from which the artifact is constructed.[73] In particular, there should be options for further development along the different dimensions mentioned in Section 4.2.2. This means, there should be options that allow the user:

- to express adaptations with regard to the material construction of the artifact,
- to express adaptations with regard to the construction in meaning (on the level of handling as well as on the level of intents),
- and to explore and articulate past and anticipated futures of the relevant development traces.

The first two points address the manipulation of the artifacts as a materially and meaningfully constructed object. In particular, the EUD-tool should integrate the traditional EUD features of tailorability (cf. Wulf et al., 2008) and allow to annotate artifacts (cf. Pipek, 2005a). The last point covers the aspect of ideation, exploration, and reflection upon changes in artifact construction. It connects the individual with the collective sphere of the Appropriation Infrastructure.

5.2 Support cooperative reflection in action

The boundary perspective on the design of Appropriation Infrastructure asks how to mediate between the local event and the broader spatiotemporal context. The goal is to connect the local EUD environment with a broader EUD infrastructure which connects the different participants of development traces that are relevant for the situated development. This perspective has a strong affinity to design- oriented research on collaborative tailoring (e.g. Kahler, 2001, sec. 4.2) and appropriation support (e.g. Pipek, 2005a, sec. 5.1.2).

[73] The different software-technical strategies to interweave the Appropriation Infrastructure system into the context of a wicked situation are discussed in Section 5.3.

In order to mediate between the immediate embodied reflection on a wicked situation and doing EUD as part of a social practice, the design should take users' perspective on the development of the boundary object into account. Chapter 4 has demonstrated that in the reflection on the contingent constructedness of the artifact different spheres appear (and vice versa), namely the embodied, the communalized and the socialized spheres. These different spheres reconstruct the user's perspective on the mediation between concrete development events and corresponding social-technical contexts given by the relevant development traces.

From the user's perspective, a situated development is of personal interest; yet in the development of a trace, the need can also arise to integrate colleagues or a user community into the trace's development. Therefore, an Appropriation Infrastructure should offer different rooms such as private, self-organized groups, as well as a public area where development traces can be worked on. It should enable individual design and reflection activities which refer to the experience of embodied practices. In case of communalized practices (e.g. doing EUD with co-worker or friends) as well as practices socialized (e.g. doing EUD with open user community or professional developers), the infrastructure should support the articulation in front of heterogeneous experience horizons (see Section 1.4.2), mediating between distributed production spheres and competences.

With respect to the interior design of rooms for doing EUD, one can make use of Oberquelle's (1994) scheme which classifies tailoring activities for groupware. Oberquelle proposes two-dimensional classification of tailoring activities which distinguished between the tailoring agents, and those affected by a tailoring activity. Both dimensions consist of the discrete items 'individual person', and 'group', which results in four different categories presented in a 2x2 cross table.

One should be aware of the limitations of Oberquelle's (1994) model. Pipek and Kahler (2006) argue that the matrix is limited in two related, but not identical points, namely the discrete and the static conception of the classification scheme:

> "The strict borders between the four different categories [of the Oberquelle matrix] mentioned blur when we try to apply them to practical examples (cf. Kahler, 2001, p. 28). It is not easy to locate the different accountabilities in the process that lead to a tailoring activity and in the process of the tailoring activity itself. While it is usually clear who actually worked with the tailoring interface of an application, it is not clear whose assumptions, ideas and decisions influenced a new tool configuration" (p. 316).

Using the terminology elaborated above, Pipek and Kahler criticize that the Oberquelle matrix studies the phenomena from a static snapshot perspective, and not from the dynamical perspective of development traces. Moreover, the snapshot view of the matrix conception

neglects the continuity of a recursive structuration process. Shifting the perspective from an isolated tailoring event to continuous tailoring traces shows the relation between the static and discrete view of the Oberquelle matrix. Often not all parts of a tailoring trace belong to the same classification; for example, the creation of a personal PowerPoint template has its source in a template provided by the local IT department, which was then adapted by colleagues for their own purposes. Thus there are transitions in a trace between different categories of the matrix. This means there must be a point when the category changes, yet because of the continuous character of the trace this point is not discrete, but blurred. Therefore some cuts in a tailoring trace exist, where the corresponding tailoring activity is somewhere in-between the categories of the Oberquelle matrix.

Nevertheless the strength of the classification scheme is to reduce the complexity of phenomena and in taking a static perspective on the design of rooms for doing EUD, the matrix provides a beneficial heuristic. Each cell of the matrix describes a specific kind of tailoring activity, for which an appropriate interior design in support of these activities needs to be created.

However, interpreting the matrix as a guide for the interior design of EUD rooms the meaning of the dimension slightly differs from the original intention (which focuses on a classification of activities). The first dimension does not directly focus on the tailoring agents, but on a cooperation structure that should be supported by the architecture of that room. Also, the second dimension does not directly focus on persons affected by a tailoring activity, but on the intended scope of validity of the tailoring activities. In addition, we should distinguish between a personal reflection, reflecting in a private community and the reflection of a public community. This differentiation should also take into account the design of rooms for doing EUD.

In summary, we arrive at a two dimensional scheme with the items *personal*, *group* and *public oriented* to classify the different EUD room conceptions. This leads to a 3x3-matrix with nine entries. The matrix of EUD rooms is presented in Table 2.

Table 2 Classification of EUD purposes, shaping the interior design of the rooms for doing EUD

		***C*ooperation structure in doing EUD**		
		1. personal centric	**2. communalized centric**	**3. public centric**
Effect scope of construction change	**1. personal scope**	• individual reflection and adaptation	• individualization supported by a self organized group • individualization supported by a friend/colleague	• individualization supported by a public community
	2. closed, group scope	• other-directed administration of the artifact of a group	• collectivization[74] of commonly used configuration / convention	• collectivization supported by a public community
	3. open, public scope	• product development in a closed environment	• product development in a semi-open design space	• product development in a open design space

Applying the analytical 'boundary object'-model of Chapter 4, we see that the rooms are related to different kinds of mediation between different perspectives on the development of the artifact, and should provide different means to enforce a change in the artifact construction.

From the normative point of view of an actively participating end user, not all possible rooms are of equal interest. For example, the role of the end user in rooms of type 1.2, 1.3, and 2.3 illustrated in Table 2 is mainly consumptive, not productive. This means that the interior design of these rooms does not follow the spirit of the EUD idea in a narrow sense, and therefore the cells are colored grey. In addition, one can expect that a public individualizing or collectivizing of a particular artifact presents an exceptional case in practice and therefore, it can be assumed that there is not any need for special rooms of type 3.1 and 3.2; so the cells are presented in grey.

Thus, the interior design of rooms of types 1.1, 2.1, 2.2 and 3.3 are of primary interest for the design of Appropriation Infrastructures. In the following, we want to give a brief outline of the interior design of these rooms:

[74] The term collectivization emphasizes that the intended scope of the EUD activity is not the individual artifact, but the shared artifact used in the group.

Room type 1.1 - Private rooms for further development of the individual artifact: Schön (1984) mentions that design is a talk back with the situation in question. Private rooms are provided for such personal conversations between user and artifact. In order to support doing EUD at the personal level, the rooms should provide different options for reflection and adaptation as mentioned in Section 5.1. The rooms should also provide means to store changes in the construction of the artifact. Additionally, it should be possible to store other data which have become relevant in the specific constellation development traces stored in this room. From the local point of view, the scope of change in the construction and the access to this data should be personalized. From a physical point of view, the data can be stored on the local computer of the user, but also on the server (e.g. in the case of web-based applications).

Room type 2.1 - Self-organized rooms for the development of individual artifacts: The self-organized rooms should enlarge the architecture of the private rooms by additional groupware features. Self-organized rooms should contain features of a self-organized administration and access control and means to support EUD awareness, as well as features for computer mediated cooperation.

Budweg, Stevens et al. (2008) have conducted an empirical study on the strategies of group-coordinators to establish artifact usages in a group. This study has demonstrated that we can differentiate between strategies for taking care of usage and strategies for usage enforcement. In case of usage care taking, the group-coordinator tries to reflect on the usage from the perspective of the others. A system can support this perspectival take-over if it makes the individualized use and the configuration of the artifact visible. In the case of usage enforcement, the group-coordinator will change the shared working environment to fit the general interest of the group as perceived by the coordinator. Group usage is either directly enforced with the help of group effective configurations, or indirectly through sanctioning of deviant behavior. While the support to take care of the group falls under the interior design of rooms of type 2.1, the support of group enforcement is part of the interior design of rooms of type 2.2.

Room type 2.2 - Self-organized rooms for the further development of the shared artifact: The architecture of rooms of type 2.2 is identical to that of rooms of type 2.1, with one important difference. Rooms of type 2.1 focus on the change of the construction of individual artifacts, while the interior design of rooms of type 2.2 supports change in the construction of a shared artifact. As in the case of type 2.1, there is a need to reflect cooperatively

on the individual artifact's construction. However, in addition to this, there is a need to express, to store, and to enforce a change in the construction of shared artifacts.

There is some research to cooperative EUD cooperative EUD (e.g. Wulf et al., 2008, Kahler, 2001, Budweg et al., 2008), nevertheless on the level of technical support as well as on the level of empirical studies, this issue is still insufficiently explored in practice. This is in particular true for the question of how to merge individual perspectives with group perspectives.

Room type 3.3 - Open Design Space as rooms for End User Participation: The architecture of rooms of type 3.3 aims to provide an Open Design Space (Budweg et al., 2009) that supports social creativity and user innovation. Such a design space should connect the continuous development of software systems with constant participation by its users. In opposite to the self-organized rooms, in an Open Design Space people with different interests and cultural backgrounds can meet.

From the user perspective, there is a need to map the use context on public available resources (which covers the access to relevant information as well as to relevant agents). In particular, such rooms should support to make integrative experiences (see Section 1.4.3). Therefore it should provide means to actively present relevant information/actors of development traces that are relevant for the actual situated development. In addition, the room should provide features that allow a self-controlled retrieval of such relevant resources.

From the general, political point of view there is a need to articulate, negotiate and rate design issues. Another important point is the management of the independent, but interdependent discourse and development traces. From the user perspective, the design discourse where the user contributes should be transparent for him. In particular, the user should get feedback when a design/discourse trace which is relevant for him, is developed further by somebody else.

Supporting the dynamic process character of doing EUD: As argued above, this involves the creation of development events embedded in continuous development traces. In this process, the type of cooperation and the scope of the effect might be changing. For example, if somebody starts with a personal reflection on the construction of his individual artifact, after a while they might include a colleague in their EUD activities, and perhaps as the result of this cooperation, the users decide that it is useful to not change the individual artifact, but the shared one.

The design of an Appropriation Infrastructure should support the dynamic character of doing EUD. In particular, the interior design of the rooms should be prepared for this dynam-

ics. From modern architecture, we know at least two different strategies to support this kind of flexibility, namely supporting the moving of one place to another, and supporting the modification of places.

- *Support movement from one room to another*

Moving artifact modifications means that parts of the state and of the history of a situated development trace are moved from one place to another. The major prerequisite is the objectification of the changes made on the specific artifact (cf. Kahler, 2001, p. 36). Therefore, the user should be supported to extract the modification of interest made from local context and packaging the modification into a transportable form. The interior design of the rooms can support these in three dimensions:

a. it should make visible what was modified,
b. it should provide the means to select which parts should be moved to a new domicile, and
c. the moving of one room to another should be supported by a standard architecture for rooms and the interior. s

Moving modifications from one context to another is confronted with problems from all three dimensions. For example, it might not be possible for a user to select the specific parts of the modification, instead she must buy the whole package. Or the other way around, she must extract every single change separately which makes the extraction and transportation complicated and error prone. In addition, setting up the new rooms one might become aware that the modifications made in the old context do not fit the new context.

One strategy to prevent such frustrations is to not move the room, but to change the character of the old room.

- *Support the modification of rooms*

The second strategy is to modify the character of a room instead of transferring the modification. The second strategy can be illustrated by Eclipse configurations like the web-based 'Yoxos on Demand'[75] that should support the configuration and deployment of Eclipse. With such tools, the user can select his personal set of Eclipse components and configure the components, together with the configuration of parameters called profiles. These profiles are typically used for personal purposes, however, the ethnographical studies conducted in the CoEUD project have demonstrated that such configurations are shared among team members . Although the actual version of Yoxos on Demand does not have an explicit con-

[75] See http://ondemand.yoxos.com (27.2.2009)

cept for sharing profiles in a team, we can observe in these empirical studies two different grass-root strategies to modify a personal room to make it more communal.

The first strategy made use of the feature that for every profile a unique URL is generated that allows downloading the corresponding individualized Eclipse installation. Some people copy the URL of their 'personal' profile, and send it to colleagues. This grass-root strategy enables different collaborative scenarios. First, one can use such a strategy to prepare a template of a working environment that will be shared in the group. Second, it provides a way to make the personal individualization of the working environment transparent to team members. Third, it provides a way to create a collectivization of a shared working environment. Which means, this grass-root strategy can be used to modify the use of the room from a personal use (type 1.1), to use it for group provisioning (type 1.2), for group supported individualization (type 2.1) as well as for collectivization (type 2.2).

The second grass-root strategy supports some aspects of collectivization in a more adequate way than the first one. The second strategy works like a flat-sharing community. Each member of the community gets a copy of the electronic key[76] to the room for every member of the group. Since not every system supports the copying of keys, the digital simulation of this is based on the model of "password sharing" (cf. Stiemerling and Wulf, 2000). This allows every member to change the shared profile, however, some features of collaborative EUD, like traceability, are not well supported by the design of rooms.

This brief example illustrates the strategy of room modification to deal with the dynamic character of development traces. We have also seen that the complexity of the modification is reduced if the modification of a room does not go along with the physical moving of the room (e.g. from the local client of the user to a shared used backend system). In addition, the example also demonstrates that such strategies can be utilized by users even if this was not planned by the designers. However, even if it is possible to use the room differently, the architecture of the existing room may not be the best one for the modified purposes.

Therefore, the evolvability of rooms for doing EUD is an open topic for EUD research. Such research might benefit from a look at the CSCW literature, studying how a Groupware system deals with the evolvability of shared workspaces.

1. Layering rooms and traces

A third strategy is the layering of rooms and traces. This strategy is grounded in the special properties of the digital material which allow a temporal, virtual merging of rooms and

[76] Typically electronic keys are realized by a username-password pair.

traces. The idea of layering rooms is to provide a uniform user experience that allows connecting information from different rooms, although the rooms remain separate from each other.

5.3 Interweave the Design Context in the Use Context

Another issue that has to be addressed by an Appropriation Infrastructure is how to connect the underlying communication infrastructure with the rooms for doing EUD in the situated development. To answer this question, it is useful to take up interpretations of Direct Manipulation in Activity Theory, and combine this with Mørch's conception of Application Units.
Mørch's work on tailorability faced the problem of how to decrease the cognitive burden of shift from the use context to the tailoring context (cf. Mørch, 1997a). He interprets the problem not only as a technical one, but - influenced by the work of Fischer – as a problem of knowledge sharing. Mørch and Mehandjiev (2000) further elaborate the idea of Application Units (AU) emphasizing the collaboration nature of EUD.
The core idea is to compose applications out of partly autonomous and usable building blocks, the AUs. The internal structure of an AU is based on three different but coupled representations:

(a) the interface, shaping the user experience with an AU,
(b) the underlying code of AU, which serves as an algorithmic sign , interpreted by the human and executed by the machine, and
(c) the rationale explaining the social-technical context of the AU.

Mørch and Mehandjiev (2000) illustrate this idea by a Basic Draw, that covers all to three aspects of interface, rationale and code (cf. Figure 10).

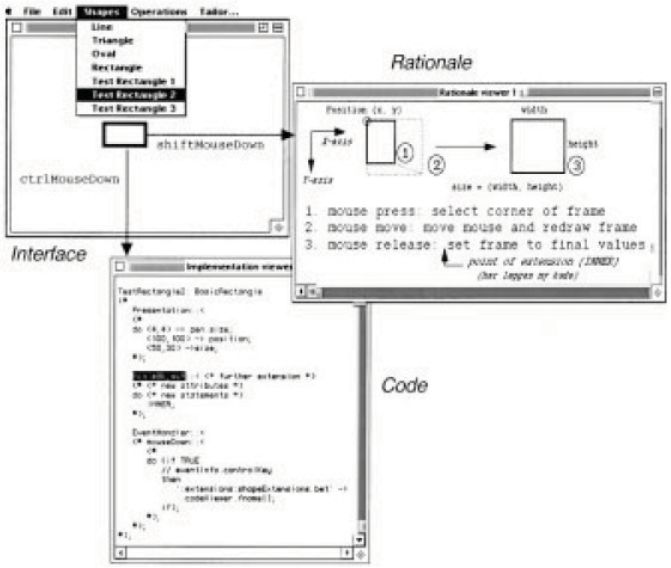

Figure 10 "The BasicDraw application consists of application units, and each application unit has three aspects: interface, rationale, and program code. The screen image shows the three aspects of the Scale application unit for rectangular objects" (figure and caption taken from Mørch and Mehandjiev, 2000, p. 89).

The AU mediates between the user experience and the underlying mechanism, which is co-responsible for the experience. Moreover, influenced by Mørch's knowledge-oriented focus, Mørch and Mehandjiev (2000) highlight that the representations of the AU also present a (one-way) communication between developers and users.

From a Bødkerean perspective, the appearance of the expressive boundary object in a breakdown situation can be interpreted as the shift in which the artifact does not mediate any longer between user and work-material. Instead, the artifact mediates between the user and the work-tool which should be directly manipulable. From a Mørchean perspective, the work-tool can be interpreted as Application Unit, where the expressiveness of boundary object presents the surface of the underlying design discourse.

For the purpose of a general architecture, the challenge of the design of Appropriation Infrastructures is to combine the thinking of Bødker and Mørch. This can be done in an analogue manner to the generalized boundary object conception discussed in Chapter 4, which combines the two roles of the artifact mentioned in Fischer's (1999) conception of boundary objects. Drawing on the analogy, an Appropriation Infrastructure should support in a wicked situation the direct manipulation of the work-tool, and enable access to the program code which is responsible for the behavior of the work-tool. Moreover, Appropriation Infrastructure should provide a direct access to the underlying design discourse environment, to support the transition from the expressive to the social boundary object.

Technically, the design should interpret the user interface as the semiotic skin of an underlying boundary object, which mediates between the interaction behavior and the corresponding material construction as well as the use context of corresponding design discourses. From a design perspective, the underlying boundary object needs to be appropriately interwoven into the user interface. A requisite of the interweaving is the existence of an algorithm that identifies in the use context (boundary) objects of interest in a heuristic manner.

In the following, we discuss two heuristic strategies. Firstly the strategy of direct activation (Wulf and Golombek, 2001) is presented, which uses the temporal context as a heuristic to identify the underlying program code which is related to an actual breakdown situation. Secondly, the CHiC strategy (Stevens and Wiedenhöfer, 2006) offers an alternative strategy, which relies on the spatial context as a heuristic to identify (boundary) objects of interest.

5.3.1 Heuristic use of the temporal context

The first design heuristics is based on the temporal context of the actual use situation. This heuristic is based on the assumption that the breakdown occurs when the application of an operation to change the work-material did not function as expected.

Such a design heuristic is used by Wulf and Golombek (2001) in their conception of direct activation: “Tailoring is needed when users perceive the effects of a function’s execution, which does not lead to the intended effects” (Wulf and Golombek, 2001, p. 254).

In their work they apply the direct manipulation paradigm to the case of tailorability to tackle the problem of finding a tailoring function when it is needed. The principle of direct activation is based on a function-oriented perspective of software applications. Following the conception of direct activation, a software application is given by a set F of functions $f_{tailored}$(ui, oc), with ui as the user interaction that triggered the function f and oc as the change of the object of interest. The index $_{tailored}$ is the tailoring of the function. A subset of F is T of the tailoring functions t(ui, fc), that allows to change the function of interest. In such a model, the design principle of direct manipulation means to continuously represent the object of interest and the functions $f_{tailored}$(ui, oc), which allows a manipulation of the object. Based on this model, direct activation can also be described as a kind of meta-direct manipulation, in which the functions to manipulate the function of interest are also represented.

Wulf and Golombek’s (2001) function-oriented model of direct activation can easily be adapted to modern software applications which are based on an object-oriented, pattern-based software architecture. One of the demands of direct manipulation is that the execution of operations should be reversible. That is why modern software applications support the undo and redo of manipulations of the work-materials. Typically, this feature is realized with the help of the command pattern as it is described in Gamma et al.(1995, pp. 233). One of the core duties of the command pattern is to record the history of the operations that are applied on the work-material. A stretch that illustrates how a command-oriented software architecture must be extended to support a direct tailoring of the work-tools is presented in

Figure 11.

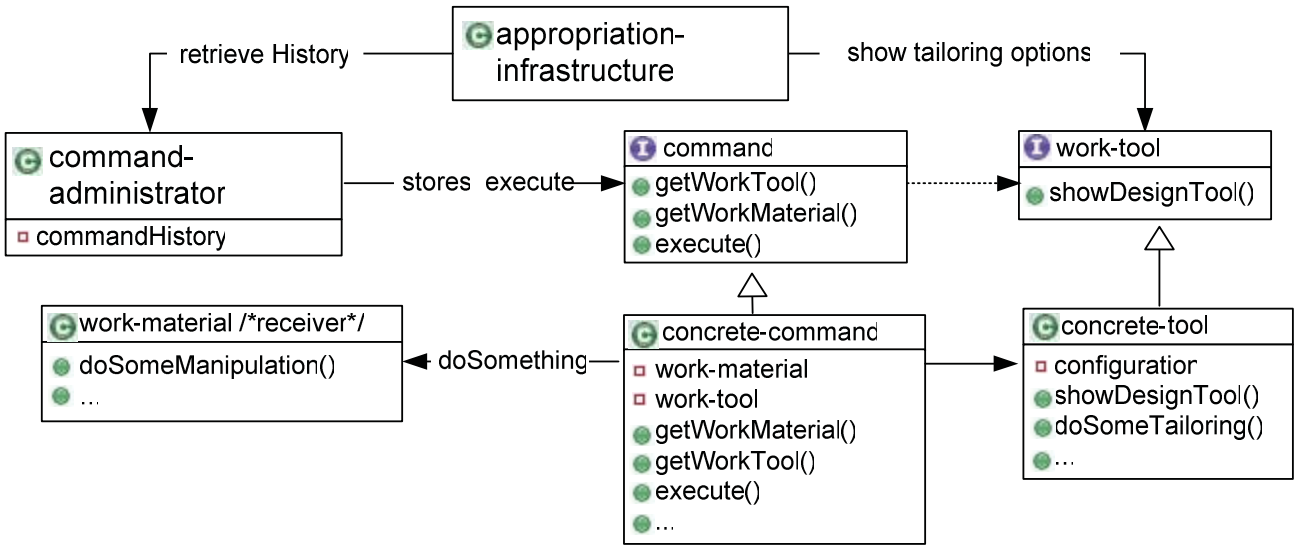

Figure 11 UML-Class diagram illustrating the realization of a temporal strategy based on the command pattern (adapted from Gamma et al., 1995, p. 233).

The function of the command-administrator is to record a history of the commands which have manipulated the work-material. In the occurrence of a breakdown situation, the Appropriation Infrastructure can retrieve with the help of the command administrator a history of commands which were responsible for the (direct) manipulation of work materials. From this specific history of each work material, the list of past commands and corresponding work tools can be deduced (cf. Figure 12).

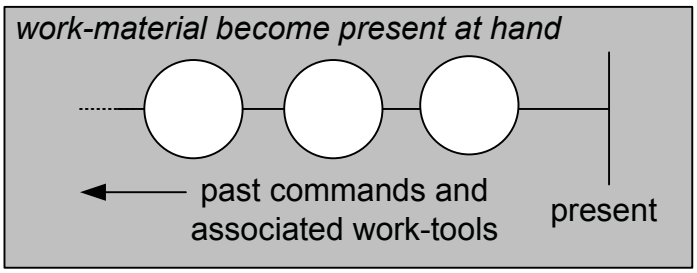

Figure 12 Retrieve the work-tools that are associated with the actual work-material becomes present-at-hand

In a breakdown situation, the user can ask the Appropriation Infrastructure which work-tools were responsible for past modifications of the work-material and to provide a direct access point nearby the actual presentation of the work-tool in question.

This strategy works well for a retrospective analysis, when the user can reflect on the produced trace of action and its corresponding computational behavior. However, the strategy assumes that the user executes the appropriate function, even if the function did not lead to the intended effect (cf. Wulf and Golombek, 2001, p. 254). However, in Section 4.2 we learn that wicked situations also arise, because a function does not exist, or it is not found. In such situation the user has no idea which function he has to execute in order to produce the intended effects. Because of the fact that in such situation the work-tool in question has not

been used before, the strategies to identify a relevant boundary object with the help of a temporal context will not succeed. Therefore, it makes sense to complement a temporal approach with other strategies.

5.3.2 Heuristic use of the spatial context

An alternative strategy to the temporal approach is to refer to the spatial context of the actual situation of use, exploiting the fact that computer applications today typically have a graphic user interface that follows the Direct Manipulation paradigm. Such a spatial strategy is motivated by aesthetical dimension of wicked situations, where reflection is bounded to presence. In addition the strategy is motivated by the heuristic that in a breakdown situation one expects to find an appropriate work-tool in the direct spatial surrounds of the work-material. In particular, in the idealize case of Direct Manipulation, the work-tool in question will be visualized in the direct spatial surrounds of the work-material. In such a case there will be no difference in the visualization of entrance point suggested by Direct Activation and the visualization suggested here.

In order to operationalize this strategy, it is assumed that the spatial context of the expressive boundary object refers to the “set of pixels generated and managed by a computational process that is the result of the computer interpretation of a program P” (Foglia and Piccinno, 2005). In this interaction, the pixel becomes an essential element of an algorithmic sign (Nake, 2001), so that mediated computational semiosis is constituted by the computer program, and intentional semiosis constituted by the user.

In order to reconstruct the semiotic process from a user perspective, I conducted a small empirical study with five ordinary computer users. A second empirical study was carried out by Grüttner , and arrived at similar results.

The empirical studies have focused on the sense-making process, trying to reconstruct how users create signs out of the pixel set. The reconstruction tried to detect patterns in the form of the produced signs, and not so much to identify patterns related to the content of the signs. In other words, patterns in the syntax rather than in the semantics of signs are explored from a user perspective. In the empirical study, the users got a snapshot of several screenshots of known and unknown programs, and were subsequently asked to highlight their points of interest.

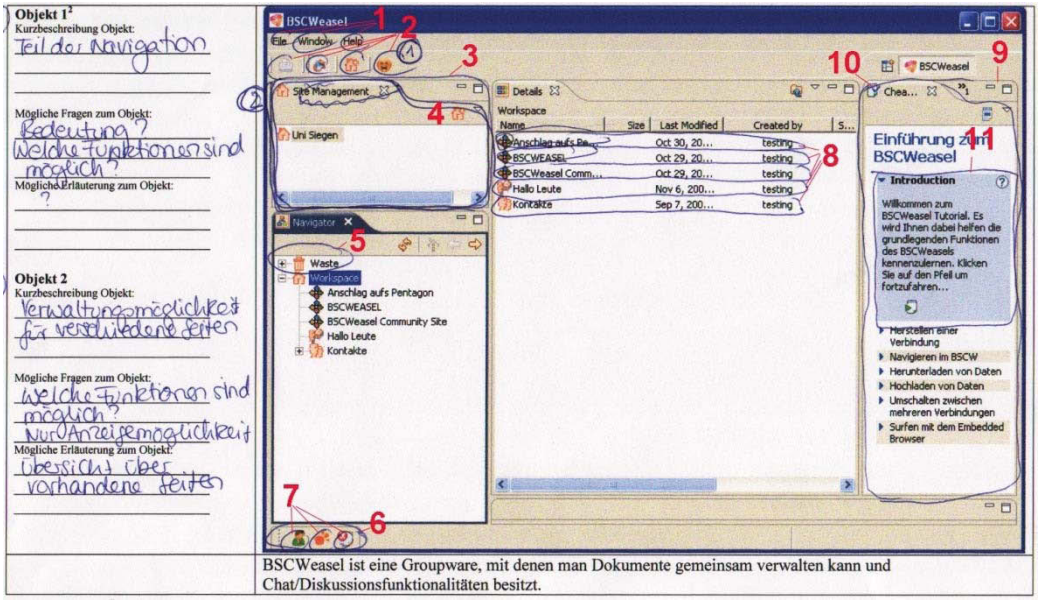

Figure 13 A snapshot that was annotated by a participant to highlight objects of interests

The participants of the study produced a list of annotated screenshots that resemble the one reproduced in Figure 13. These annotated screenshots presented the data corpus for an additional analysis to reconstruct patterns in the syntax.

Typically, users mark areas that are places for interaction. This means, the perceived object of interest syntactically correlates with the visual areas for interaction produced by the computer. Moreover, the way users give the pixel a meaning is related to the widget hierarchy of the interface. A widget is a concept in modern computer applications which facilitates a specific user-computer interaction and appears as a visible part of the application's interface.

In modern computer applications, the graphical user interface is created with the help of GUI frameworks and so called Interface builders, "moving some aspects of user interface implementation from conventional code into an interactive specification system" (Myers et al., 2000, p. 8). Today, common GUI frameworks like AWT/Swing, SWT/JFace or Qt cover an object-oriented Widget Toolkit.

Object-oriented software applications that make use of GUI frameworks typically do not have any direct access to the graphic context, apart from when widgets are used to encapsulate business logic, separating it from interaction logic. Therefore, widgets are typically the smallest unit in the object-oriented management of the GUI. This GUI is commonly constructed in a cascading manner, with widgets added directly on top of existing widgets. Typically, widgets are realized with the help of the composite pattern as described by Gamma et al.(1995, pp. 163).

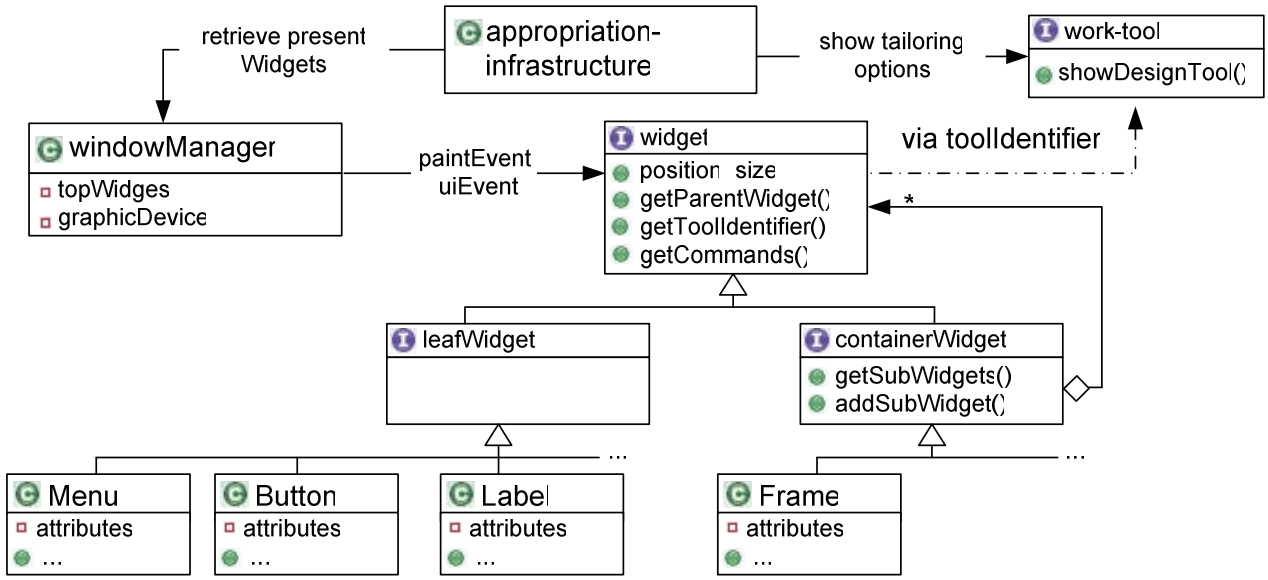

Figure 14 UML-Class diagram that illustrates an realization of a spatial strategy based on the composite pattern (adapted from Gamma et al., 1995, pp. 163)

In a GUI framework, the typical function of a windowManager is to manage the different windows of an application and the associated widgets. A widget has a size (typically measured in pixels) and a position, which is relative to the position of the parent widget (or in the case of a top widget, relative to the position of the associated window). There are two subclasses of a widget: leaf- and containerWidget. In opposite to a leafWidget, a containerWidget is a widget that has a list of subWidgets. The objects of the list are elements of the base class widget.

With the help of this data structure, the widgets of an application window are organized in a hierarchically framed topological space. This data structure makes it possible to retrieve the list of present widgets that are associated with a pixel set.

One option for integrating the Appropriation Infrastructure into the GUI framework is to connect the system with the windowManager (see Figure 14), so that in the occurrence of a breakdown situation the list of the widgets actually present can be retrieved. In addition, the widget class must be enhanced by a member function that directly delivers corresponding work tools, or an identifier that can be used to retrieve corresponding work tools. Such an extension would allow the Appropriation Infrastructure to deduce the list of the actually present widgets that visualize corresponding work tools (see Figure 15).

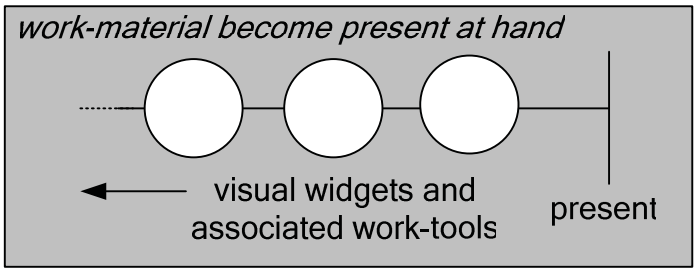

Figure 15 Retrieve available work-tools that are associated with the actual work-material that has become present at hand.

In a wicked situation the user can ask the Appropriation Infrastructure which work-tools are available in the actual situation and allow modifying the work-material. Normally modern computer systems have the feature of context help, which is interpreted as a special form of a spatial strategy where the user can press the key F1 in the case of a breakdown situation. In the case of Eclipse, this feature is part of the Eclipse Help framework. Pressing the key calls the Eclipse Help Framework, which uses a spatial strategy to identify the widget actually selected. The actual widget does not refer directly to an entry in the help text database. Instead, the help framework asks the widget for a help identifier which serves as a key to search the database.

However, the feature only works if two things have been done during design: first, the designer must have anticipated the wicked situation, and second, the designer has to identify the appropriate place in the source code, and set the help identifier of the widget to an appropriate value.

In other words, in the first step the designer might identify a code line like:

```
widgetOfInterest = new Widget();
```

In the second step, the code might be extended by a function call that sets the help identifier. The extended source code might look like:

```
widgetOfInterest = new Widget();
widgetOfInterest.setHelpIdentifier("BBD17F3C-9ED3-11D4-845B00E0293D68BB"); /*GUUID*/
```

In the BSCWeasel project (see Chapter 6) we could gain practical experience with the Eclipse Help Framework in the following dimensions:

1. using the framework to add context help for own components,
2. using the framework to add context help to 3rd party components, and from
3. the typical use of the framework by the designer of 3rd party components.

The first and the second dimensions describe our first-hand impression of the benefits and pitfalls of using the framework, not only to provide help for our own components, but also to provide help for 3rd party components that we re-use. The third dimensions describe our

experience, comparing our first-hand impression with the adoption of the framework by other designers.

The first kind of experience was shaped by our usage of the framework to add context help to self-produced components. Because of the situatedness of work activities (cf. Suchman, 1987) it was a tough challenge to find an appropriate position in the source code map it to an anticipated work context in using the application. In addition, our experience was that the manual maintenance of context identifiers would also be quite error-prone.

Because of the fact that the realization of the BSCWeasel (see Chapter 6) depends to a large extend on using 3rd party components, we also gained experience how well the framework is adopted by others (dimension three), and how well the framework supports a designer to extend the work of other 3rd party designer (dimension two). In these dimensions the Eclipse Help Framework support the designer insofar as it allows to create additional help entries for help identifiers that are specified in different 3rd party components. Technically, the framework provides an extension mechanism that allows new components to extend the help database subsequently.

To realize the BSCWeasel we use a lot of official Eclipse components, but also 3rd party components that are implemented by independent designers. In both cases, we want offer additional context help, where we saw that is needed, but not provided, since the designers may either forget to write help texts for an identifier, or place the context identifier at the wrong position in the source code. However we run into problems because of the extension mechanism only works if the designer of the 3rd party had added the help identifier to the widget in question, which is often not the case. Therefore it was often not possible to provide appropriate context help. So in summary, the experience with the extension mechanism as well as the typical use of the framework in practice (our own as well as of others) demonstrates that the Eclipse framework is limited to supporting the anticipation and implementation of context help.

The analytical considerations of Chapter 4 have demonstrated that in a wicked situation the expressive boundary object can be interpreted from its semiotic structure. The expressive boundary object serves as a sign that mediates between an interpretant and an object of interest (OIs). The OIs that appears in a breakdown situation can be defined as the universe of all potential objects of interest. A subset is the space of all OIs that could be referenced by marking an area in the actual presence of the GUI. The extension of this space was studied empirically by the analysis of user's reference practices described above. An-

other subset is the space of OIs that are anticipated by designers (or more precisely, that are incorporated in the design). The extension of this space was studied empirically by the analysis of the implementation of context help, making use of the Eclipse Help Framework.
The comparison of spaces reveals that they have different extensions (see Figure 16). In other words there is a gap between use practices to refer to OIs and the design practices to incorporate OIs.

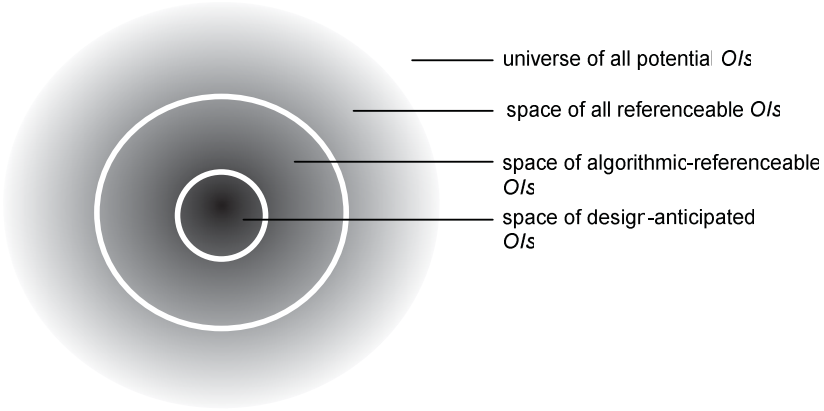

Figure 16 Qualitative characterization of the different OIs' space extensions

Based on this observation a novel, heuristic approach has been developed that makes use of patterns in the production of pixels that serve as visual carriers of meaning. The goal of this novel approach is to minimize the gap between the design and the use practice by introducing the additional space of algorithmically referenceable OIs. This means, the user's object of interest must algorithmically map to stable context identifiers.
At least three requirements for the quality of automatically calculated context identifiers have been identified:

1. the algorithm should produce an identifier that is stable in time and space,
2. the user should be able to reproduce the condition that leads to a particular context identifier, and
3. the algorithm should capture semantically meaningful use contexts. In the best case, only a particular use context is related to the context identifier.

The first requirement stems from the fact that the calculated identifier serves as a reference to an (expressive) boundary object that mediates between the here-and-now and once-and-there of the artifact present-at-hand. Hence, the identifier should be stable in time and space. The traditional solution for fulfilling these requirements is that application developers integrate a unique help identifier to the source code. However, one of the goals for a novel approach was to provide references to OIs even on places which were not planned by the application developers. In this situation, the requirement was not easy to fulfill.

The second requirement is a corollary of the circumstance that the identifier is associated with a boundary object that mediates between time and space. In the case of person-centric development trace, the user should be supported to go back to previous use contexts and the design remarks made in these contexts. Moreover, in the case where the identifier serves as a connection between a use context and a group- or public-centric development trace, a user should be notified about events that happened in that trace. In order to support the mediation between use context and development traces, the notification should be supported to go to a place where the user can see the initial use context and the associated development events produced by herself or other persons.

The third requirement is derived from the fact that the source code and the runtime information provide a large amount of information about the application state. However, a major part of this information is only technically motivated and has no meaning to users in its own context. For example, a prototypical implementation of an algorithm has calculated about 60 graphic controls in the user interface as shown in Figure 18 (right). Yet some of them are more or less meaningless to the user, e.g. the composite controls which were only introduced to control the layout of the GUI.

2. Using class name information

The class name of an object fulfill the first requirement (modulo versioning), but many class names do not convey any application-specific information (in particular the Class *java.lang.Object* is too general). Nevertheless, through the existing coding practice, in some situations the class name is a good candidate for a context identifier.

For example, the complete context menu approach of the *JFace* part of Eclipse depends on the class inspection mechanism. Eclipse *JFace* is a Model-View-Control (MVC) architecture that recognizes tables, trees or other standard user interfaces. In *JFace*, the standard UI element (like Table or List) is connected to the application-specific model by means of content providers and content labels. The developer of the model should express the application-specific semantics of the model which are implemented by the model object by means of creating a domain specific sub-class.

This allows third party developers to extend the context menu by using an Eclipse extension mechanism. This mechanism retrieve classname of the domain-specific model via the Java reflection feature (cf. D'Anjou et al., 2005, chap. 7) and ask the Eclipse framework for the list of extensions that are associate to this classname.

We can use these coding conventions of classes and interfaces for our purposes in order to calculate an identifier for the domain specific model.

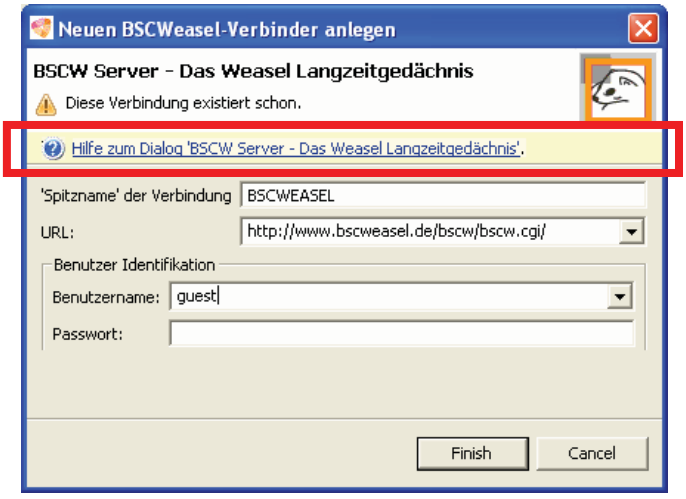

Figure 17 Integrating context-specific links to jump to the right place in the Wiki Systems.

Another example of the strategy to interweave a link to a boundary object into Eclipse dialogues as shown in Figure 17. In the case we make use of the common Eclipse coding practice that developers write a new class when they add a new dialogue to their application. This leads to an individualized class name, e.g. in the case of Figure 17, the absolute name of the class was *de.uni_siegen.fb5.bscw.siteview.views.BSCWSiteCreationPage*. This work practice of developers can be used to refer to the use context of the dialog.

Roughly spoken, the algorithm works as follows: The algorithm retrieves the title of the original dialogue in order to build the name of the link. In addition, the algorithm also retrieves the actual class name of the dialogue using the polymorphic feature of Java. It uses this class name[77] to generate the context identifier.

3. Using the object identifier

In object-oriented systems like Eclipse (as written in Java), each object has a unique object identifier. However, this identifier cannot be used as a reference to a use context, as it does not fulfill the first requirement. In most cases, the object id is only transient information, and different instances of the same application will produce a different object id for semantically identical objects (like a menu button in the toolbar).

4. Using information stored in hierarchically structured widgets

Although the strategies set out above cover many cases, some interesting points are not captured by these strategies. For examples, a menu in the toolbar is not covered when it was integrated by an application not using the Eclipse extension mechanism. In such situations, there is a need for an alternative way of calculating a context identifier.

A generalized strategy is to use the hierarchical, topological data structure of the widgets. In general, the calculation-stable context identifier can use the information stored in this data

77

structure as well as the information that is stored in the individual widget. The generalized strategy should rely on a set of heuristic algorithms which use a mixture of information to fulfill the requirements of a good context-capturing mechanism. For example, in the case of a menu in a toolbox, one can use the icon and the title of the menu to generate an identifier. The design rationale of these strategies is that both items (icon and title) are signs that convey the application- specific meaning.

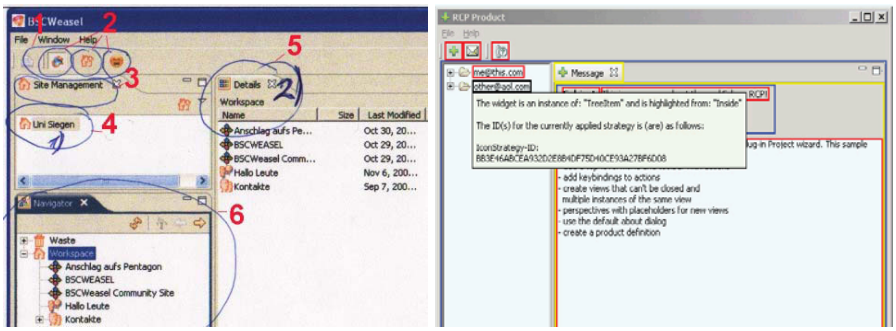

Figure 18 Highlighting the point of interest: (left) from a user's perception and (right) calculated by the computer (the tool tip refers to information that can be gathered by algorithmic reflection on current state of the application).

Software-technically, a generalized strategy can be implemented by using the runtime reflection feature to gather information that allows a computational identification of the point of interest.

As a part of the design study, a generalized strategy was implemented, using the results of the mentioned study on snapshot annotation as a reference point. The strategy calculates context identifier on the basis of the information that is stored in the hierarchal widget structure, so as to simulate the observed snapshot annotation practices. Figure 18 illustrates the results of the attempt to simulate in computation the observed snapshot annotation practices. The left picture presents a snapshot which was annotated by the user, the right picture presents a snapshot that was computationally annotated. The tooltip in the right picture shows the calculated context identifier.

5.4 Modular software architecture for Appropriation Infrastructure

The holistic perspective on the design of Appropriation Infrastructure has to integrate the different facets into a coherent software-technical conception. In particular, a technical infrastructure is needed to support end users in reflecting on their current tool use and stimulate their creativity- and problem-framing competence and map the design issues which appear in local reflection on corresponding design issues expressed in other development

traces. A reason why other development traces are relevant is because one works in a shared infrastructure (Pipek and Kahler, 2006) (see also the Excel example in Section 1.1). Supporting integrative experiences and sharing appropriation paths with the help of an Appropriation Infrastructure should foster collective processes within the user community (Fischer and Giaccardi 2006), and embed their results into a transparent (re-)design process in order to reduce the gap between production and consumption. Moreover, developers should be supported to be aware of the usage of an application as well as of possible or actual breakdown situations. In addition, they need tools to efficiently implement changes or re-design an application.

A first outline of the technical conception of such an Appropriation Infrastructure implementation was presented in Stevens et al. (2009a).The technical conception was also influenced by approaches to support user-user communication. The design relies on Pipek (2005b) work, which proposes 'use discourse environments' to support and visualize communication among users which relate to the use or configuration of technology.

The technical infrastructure is supposed to coordinate the fragmented character of distributed work and to mediate the fragmented character of distributed experience. Therefore, the goal of the technical infrastructure was to address two related aspects:

(1) to bridge the fragmentation of distributed experience by stimulating knowledge sharing among the agents that become relevant in the growth of the particular shared infrastructure[78] by providing communication channels to reflect upon an application's use.

(2) to bridge the fragmentation of distributed work by providing communication channels between consumption and production spheres.

The following gives a brief outline of a component-oriented concept of a generic architecture for an Appropriation Infrastructure. The architecture is based on the needs detected in the earlier analytical reflection, and on the practical experiences in realizing parts of the Appropriation Infrastructure within the Eclipse framework (see Chapter 6). The major goal of such a modular architecture is an efficient implementation of software-technical support for appropriation work. The modular concept is a revised version of the architecture published in Pipek, Stevens et al. (2008). It makes the technical aspects of supporting appropriation work more clearly, but omits some technical details.

[78] Here, the artifact present-at-hand constitutes the point of infrastructure that marks the center in the particular evolution of the shared infrastructure. Typical agents that become relevant in the particular evolution are friends, colleagues, internal and external help desk, etc. (see Section 4.3).

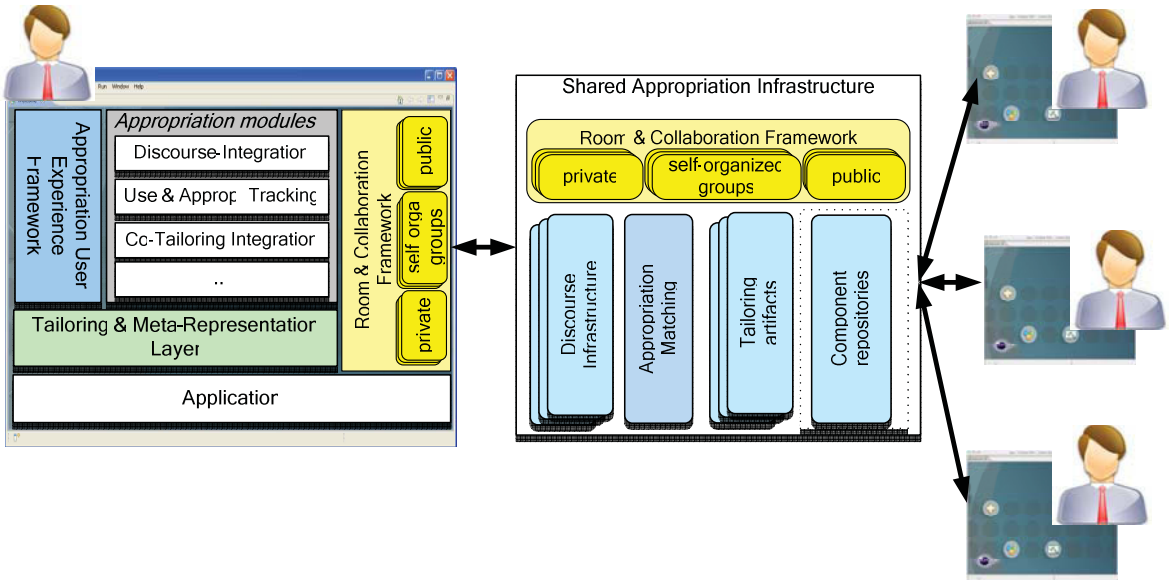

Figure 19 Diagram of a logical architecture of an infrastructure to support appropriation work in products communities

The architecture is split into a shared or backend part of the infrastructure (cf. Figure 19), and a local or client part that integrates the infrastructure into the application context. The right side of the figure represents other agents of a product community, connected to the appropriation infrastructure. This architecture describes a logical perspective on the infrastructure and does not yet constitute the physical/technical design.

- Appropriation User Experience Framework (AUEF)

The AUEF module is responsible for interweaving the shared infrastructure into the skin of the boundary object, and to guarantee a consistent user experience regardless of the modular composition. In doing so, the visual presentation, the responsible computational mechanism as well as the corresponding discussions are supposed to refer co-referentially to each other (cf. de Souza et al., 2001). This simplifies the transition between usage, usage discourse and usage modification. In particular, the design should enable direct opportunities for activation as discussed in Section 5.3. Because of the fact that several heuristic strategies exist (cf. Section 5.3.1 and 5.3.2) to interweave a boundary object into the use context, the Appropriation User Experience Framework should provide an extension point that allows to plug-in additional and domain-specific interweaving strategies.

- Discourse Infrastructure (DT)

The function of the DT module is to foster the social process of sense making and negotiation around the used technology. Discourses can be related to one's own application usage, intertwined with experiences of other actors or negotiations of common interpretations. It

should include reference to related components, as well as to additional components and configurations and patches. Moreover, it has to integrate the various discourses into the local context.

The DT module is split into two parts: a local and a shared part. The role of the shared part is to store and manage the actors' discourses. The role of the local part is mainly to integrate discourses into the application, which means, to present discourses to the user in an adequate manner, in relation to the use context. In addition, it should enable and encourage the users to actively join discourses.

- Cooperative Tailoring (CT)

The CT module will be responsible for dealing with the technical aspects of a cooperative provisioning solution. The main role of its shared part is to offer management repositories which store and manage ready-made components as well as tailoring artifacts.

The local part embeds the shared repository into the application context and should support a cooperative tailoring model. It should provide local access to the shared infrastructure, so that ready-made components and tailoring artifacts can be installed locally. Additionally, it should provide means to share local adaptations with others using the shared part of the infrastructure.

- Room and Collaboration Framework (RCF)

The RCF module is responsible to provide user management and access control functionalities. Additionally, it maps the logical room concept to the physical layer of distributed computing.

In particular, the RCF should offer rooms for the four different types of EUD activities outlined in Section 5.2. So, the RCF should offer personal, group-organized, and public rooms in order to support EUD activities that will be stored for personal reasons, within self-organized groups, and in public spaces. In addition, the RCF should provide options for changing the architecture of rooms as well as to provide services to transport modifications of artifacts from one place to another.

- Additional appropriation support features

Beside communication support, an appropriation infrastructure should identify fragmentations in distributed appropriation work and should recommend usages and user based on heuristically interpretations of patterns in the consumption and production practices. This underlines the importance of analyzing individual and collective histories of usage (Bell et al., 2006). A general architecture splits the evaluation of histories of usage into the aspect of use and appropriation tracking, which is in the local embedding as well as in the appro-

priation matching, which is located on the shared part the Appropriation Infrastructure. The feature of appropriation matching interlinks the different histories of usage, and derives recommendations. The feature can either recommend relevant appropriation practices or recommend “similar” users. In both cases, it is important to analyze the behavior of the user in order to adjust the system to them. A realization might use collaborative filter-algorithms (Burke, 2002) to support the user in finding interesting extensions and expertise related to his actual use context (see also Draxler et al., 2008).

Beside these different appropriation modules, the architecture should contain a set of common modules (e.g. component management and configuration framework). A modular conception of an Appropriation Infrastructure, as it is laid out here, should increase the extensibility and evolvability of the framework. For example, it should be possible to plug in new modules for domain-specific approaches to appropriation support.

6 Design study

To explore the idea of an Appropriation Infrastructure, a component based on groupware application called BSCWeasel has been developed. The BSCWeasel project was conducted as Open Source. The project started in spring 2004 in order to realize a flexible, rich client for the groupware system BSCW (cf. Stevens et al., 2004). In addition, different aspects of the Appropriation Infrastructure were implemented for the BSCWeasel project, and thus also tried out in practice.

BSCW (Basic Support for Cooperative Work) was one of the first web-based groupware applications. It was developed at the German National Center for Research in Information Technology (GMD) during the mid-90's (Bentley et al., 1995). It offers a 'shared workspace' which supports a group of users to up- and download documents. Additionally, awareness services, differentiated access rights, a group management tool, email distribution lists, a discussion forum, and a shared calendar complement the functionality of the groupware. The fully web-based solution of BSCW has specific advantages. Obviously, there is no installation effort on the client side. However, there are also considerable technical limitations due to the fact that BSCW just offers a thin client. There is not any redundant local storage for important files, a permanent internet connection is required, and streaming information (e.g. to provide peripheral awareness) is difficult to implement.

Therefore, we have developed the rich client BSCWeasel, which follows the basic client server architecture of BSCW to a large extent. The client-server communication was mainly realized with the help of the so called X-API, the web service interface of BSCW (cf. FIT, 2004).[79] The client has a component-based software architecture, based on the Eclipse Rich Client Platform (RCP) as the application framework (cf. McAffer and Lemieux, 2005).

Methodologically, the technical realization and the conceptual elaboration of Appropriation Infrastructure are developed in co-evolution (see also Section 1.2). This approach has the advantage that the conceptual elaboration can profit from taking appropriation phenomena into account, the disadvantage of the approach is that implementation grows organically, and does not realize the conception in the purest of forms.

[79] In the realization the problem occurred that not all interesting BSCW features are well supported by the X-API. In this case we followed a re-engineering approach. We analyzed the HTML/HTTP stream of the ordinary access via the Web browser, and built a client-side stub that extends the X-API. The client-side stub provides a local API; however a call of a method was mapped to the HTML/HTTP-based client-server communication.

In reaction to practical experiences with the use of the realized Appropriation Infrastructure presented in this chapter, and the retrospective analytical reflection presented in Chapter 5, there are some important aspects where the actual version of the conceptual framework has been changed from the initial design conception.

Table 3 Differences in the initial realization and the revised conception of the Appropriation Infrastructure

Original conception when starting the BSCWeasel project	**Revised conception that takes appropriation effects into BSCWeasel into account**
The initial design conception assumes that the different kind of EUD action (changing the material artifact, changing the interpretation of the artifact, …) are separated from each other. In addition, it assumes that a specific EUD activity corresponds to a specific social place to realize this activity. This leads to inadequate design decisions in the following dimensions:	The modular conception of Section 5.4 presents a revision of the initial design conception, becoming aware that types of EUD actions are different moments in a development trace. In addition, from the kind of a EUD action one cannot directly conclude about the kinds of social practice, where action is carried out. This leads to corrections of the initial conception in the following dimensions:
1. the initial version understands reflection about changing the design of the artifact, and reflection on changing the usage of the artifact as two different activities, instead of two different moments in a development trace	1. the EUD action and the place of doing EUD are interdependent, yet independent aspects of a development trace. As a result of this, the modular architecture of Section 5.4 treats the kind of EUD action and the room for doing EUD action as orthogonal features of an Appropriation Infrastructure.
2. the initial version neglects the need for private reflection	2. the modular architecture conception introduces the idea of personal rooms to take this issue into account
3. the initial version neglects the difference between a user community as a self-organized group, and the public use/design community	3. the modular architecture conception introduces the idea of self-organized and public rooms, which creates places where user, designer and other interested parties can collaborate.

In the following, the Appropriation Infrastructure system will be presented as it is realized in the BSCWeasel project. The implementation should be understood as a design study that is related to, but not identical with the idealized Appropriation Infrastructure outlined in Section 5.4.

6.1 Evolvability of the socio-material environment

The first goal of the BSCWeasel project was to provide an environment that is prepared for continuous development on the technical as well as on the organizational level.
With regard to technical or product oriented flexibility, the current BSCWeasel implementation is grounded in the features which Eclipse RCP provides. Eclipse is a development environment for component-based applications. Eclipse RCP is a set of core components of Eclipse (called plugins in Eclipse terminology), which allows running component-based applications on a variety of different operating systems. Moreover, the Eclipse Foundation promotes the growth of the so called Eclipse Ecosystem which enables benefiting from the results of a large community of developers. Eclipse provides a well supported and stable environment to build component-based applications. Another reason to choose Eclipse was the fact that the framework is open source. So the source code is available and enabled us to change the framework where necessary.
Eclipse implements the paradigm of "*everything is a plugin" (Gamma and Beck, 2004)*, where a plugin is in a technical sense *the smallest application unit of the Eclipse Platform function that can be developed and delivered separately (IBM, 2005).* Such a component must be designed according to the Eclipse plugin model which is an extension of the common OSGi standard. Roughly spoken, a component is a bundle of Java code, additional resources, and a description of the components' properties. Technical-oriented flexibility is basically limited to extensibility. The Eclipse Update Manager allows high-level components to be integrated at runtime into a composition to provide additional functionality. Plugins for an application are stored in specific web-sites and have to follow the update site's specification. From this site they can be downloaded to the local plugin directory.

In a first version of BSCWeasel, we basically implemented the main features of the web-based BSCW client (cf. Appelt, 2001) in a feature with a set of core plugins. Later on, we added plugins to realize new functionality. A set of new plugins offers tools for synchronized cooperation based on the XMPP/Jabber instant message protocol. We also developed a plugin which allows the fat client to deal with more than one BSCW server. Additionally, we extended the awareness functionality of BSCW and implemented a caching mechanism. This design decision has increased the extensibility of the BSCWeasel application.
One drawback of the Eclipse Framework is that compositions of plugins cannot be reassembled during runtime by end users, since Eclipse RCP does not provide any specific user interface for this. Contrary to FreEvolve (Stiemerling, 2000), Eclipse does not connect

the component structure with the corresponding elements at the user interface. Beyond extensibility, Eclipse RCP implements an interface-related aspect of technical-oriented flexibility which is part of the Eclipse workbench concept. The user interface of an application is subdivided into different areas in which different interface elements (called views) can be placed. These areas can be recursively split when needed. Users can reposition these interface elements to compose a new integrated user interface and enhance functionality by adding new views.

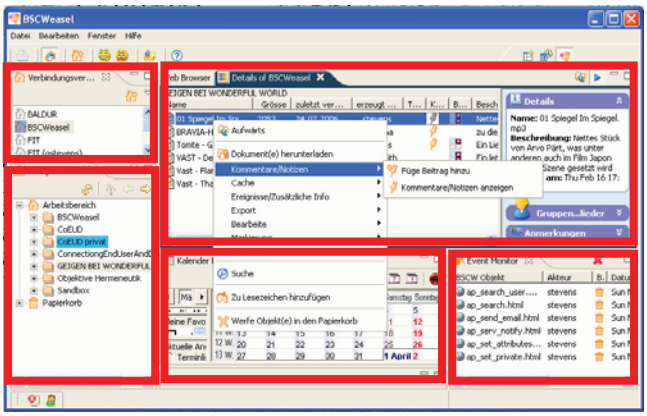

Figure 20 Screenshot of an Eclipse workbench with a set of BSCWeasel related views (outlined with a rectangle)

Figure 20 provides a screenshot of the interface of the BSCWeasel, which illustrates the Eclipse workbench concept. Typically at the beginning the BSCWeasel user interface displays only some views; with time, the user interfaces become more complex, presenting more sophisticated features (like the Event Monitor in Figure 20, which presents awareness information).

The technical flexibility of the BSCWeasel are less complex than the theoretically given EUD opportunities in research prototypes like FreEvolve (Stiemerling, 2000), Prospero (Dourish, 1995) or OVAL (Malone et al., 1994b, Malone et al., 1994a). But in the BSCWeasel project the primary interest was not to build another framework for tailorable groupware systems, but to make an existing groupware system more flexible. In respect to this intention, one has to compare the Eclipse-based architecture of BSCWeasel with the existing web-based architecture of BSCW. Such a comparison of the Web-based BSCW system and the RCP based BSCWeasel system was given in Stevens, Budweg et al. (2004). The following comparison presents a revision of these considerations.

The BSCW, like some other Groupware systems, follows the concept of web-based thin client solutions. This concept has several advantages for the end user, as there is for instance no need for installation. But from an End User Development perspective, this architecture also has major drawbacks. As the entire application is fully executed on the server

side, it is difficult or impossible for an ordinary user to fit the system into her use context. For a purely server-based system, it is more difficult to provide different scopes of validity for a tailoring activity. As a consequence, usually only the small group of system administrators has the opportunity to adapt the systems in a manner that goes beyond the parameterization of standard options. Table 4 lists the different tailoring options of Web based BSCW.

Table 4 Tailoring opportunities provided by Web based BSCW (cf. Appelt et al., 1998)

Opportunities to tailor	**Need skills and effort**	**Agent**	**Scope of validity of a tailoring activity**	**Support for cooperative tailoring**
Create new and tailor existing BSCW modules	High	BSCW-Administrator	Total BSCW server	No explicit support
Configuration of the BSCW server	Middle	BSCW-Administrator	Total BSCW server	Low community support, providing a mailing list
Personal Tailoring	Low	End User	Local	Some support, providing predefined user profiles

As seen in Table 4, the study of the tailorability of BSCW has to distinguish target groups: the individual user on the one side, and the system administrator on the other side. Mørch (1997b) has argued that we should differentiate three levels of tailorability: customization, integration and extension. In respect to this, the system administrator can tailor the web based BSCW at all three levels of tailorability, while the tailoring options for the individual end user are restricted to the level of parameterization. In addition, this kind of tailorability does not support explicitly EUD activities in self-organized groups.

In contrast, Eclipse-based BSCWeasel client's offers new tailoring opportunities to the end users. In particular, it allows a decentralized tailoring which goes beyond the existing possibilities provided by the Web based system, which also affects the "software evolvement" process. With decentralization and a component-based architecture, it will be easier to fit the system to specific contexts. Table 5 gives an overview of the opportunities offered by the current Eclipse infrastructure.

Table 5 Tailoring opportunities offered by the Eclipse infrastructure

Opportunities to tailor	Level of required skills and effort	Agent	Scope of validity	Cooperative tailoring support
(Re-) Programming components	High	Open source community	Group effect by diffusion of artifacts	Source forge and other community places
Instantiate component templates	At the moment wizards build skeletons for components only. But implementing complete plug-ins and deploying them under full control of special wizards has enormous future potential. Such wizards can radically reduce the complexity of building components for special domains.			
Mode of integration of new components into the (CSCW) application	Middle	Normally initialized by power user and diffused by sharing with colleagues	Group effect by diffusion of artifacts	Eclipse plugin marketplaces. No special community places for CSCW related Eclipse material as yet.
Degree of personalization of component configuration and tailoring of perspectives	Low	End user	Local	Sharing not supported

Table 5 also demonstrate that in contrast to server-oriented architecture, the client- oriented architecture provides new tailoring opportunities that can go beyond the intentions of the provider (system administrator) and/or the intention of the manufacturer (designer) of the software system. For example, the opportunities to extend the existing systems by 3rd party or self-developing components also enable new forms of tailorability in self-organized groups.

In summery Table 5 demonstrate that the Eclipse framework increasing the technological flexibility doing EUD. However, to shift from tailoring the individual artifact to shaping a group environment, in Section 5.2 I have demonstrated that the Appropriation Infrastructure should offer appropriate rooms for collaborative EUD. Moreover, to deal with the complex interrelation of autonomy and heterogeneity, system architectures are needed which follow the subsidiary principle. This tenet holds that nothing should be done by a larger and more complex organization that can be done just as well by a smaller and simpler organization.

With this principle applied, a centralized instance manages collective resources or provides common meeting places. Yet autonomy and creativity of groups should be restricted as little as possible. Concerning tasks that are typically completed at the local level, users should have the freedom to decide how to use and arrange the centralized services. Unfortunately, the Eclipse framework does not support the sharing of tailorable artifacts in self-organized groups. Also actual version of the implemented Appropriation Infrastructure mainly focuses on the question of knowledge sharing among users (see below). Therefore appropriate opportunities for the self-organized management of group configuration are still missing and being issue for future work.

With regard to an organizational- or process-oriented flexibility, we set up in the BSCWeasel project an agile software development process to be able to react immediately to user requirements expressed within PaDU (see Section 6.3). To bridge the gap between product- and production oriented flexibility, the developers can build new plugins or modify existing ones by means of short release cycles. We practice refactoring, as a method for architectural evolution. Eclipse as a software development environment offers tool suites to support these approaches to process-oriented flexibility, like refactoring feature. However the example of organizing Eclipse evolution outlined in Section 1.1 shows that one should make use of this option very carefully.

6.2 Collaboration among users

The goal of the Appropriation Infrastructure is to bridge the fragmentation of distributed experience by stimulating the sharing of knowledge between the parties involved with the artifact, by providing communication channels for public reflection on the application's use. The initial version of the Appropriation Infrastructure has tried to realize that goal by implementing communication channels that support the user community reflection on their software. To support collaborative reflection activities among users, we suggest making help functions highly context sensitive, and to augment help functions with the functionalities of a community system. Therefore we enhance traditional help approaches through a new concept which we called Community Help in Context (CHiC) (cf. Stevens and Wiedenhöfer, 2006). The CHiC idea draws on Wikis to integrate a user communication channel into the help system as a pre-existing infrastructure that supports the user in a breakdown situation.

The software architecture of CHiC consists of three generic software modules: Application Integration Module (AIM), Context-Aware Adaptation Module (CAM), and Community-based Help System (CBHS) (see Figure 21).

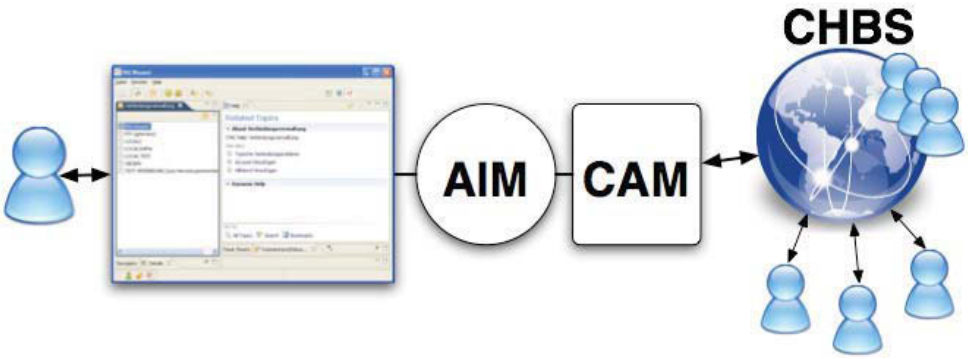

Figure 21 Architecture of Community Help in Context (CHiC)

- **AIM**

The Application Integration Module (AIM) integrates the CHiC into an existing application. The user interacts with the CHiC system through the AIM. The AIM allows asking for help inside the use context. It provides a "single-click" access to the net based CBHS-System or other help texts found on the internet (such as relevant newsgroup entries).

- **CBHS**

A Community Based Help System (CBHS) provides a public space for End User Development Environment. The CBHS can be a traditional community system enhanced with the special functionality that is needed to provide context-sensitive help.

- **CAM**

The Context-Aware Adaptation Module (CAM) mediates between the AIM and the CBHS. It adapts the CBHS (e. g. by providing the right entrance point) depending on the actual use context and/or the use history.

In the design study, we use the Eclipse Help framework (see D'Anjou et al., 2005, Chap. 22) to integrate Wiki help into the application context. The Eclipse Help Framework is highly sophisticated and adaptable, and integral part of the overall Eclipse RCP Framework. It supplies a text search capable of finding information by keyword, and a context-sensitive help that describes the particular function, views, or buttons that you are working with. You can interact with the help system on the workbench using the help view or an external help browser window. One of the features of the Eclipse Help Framework is the context sensitive help. It allows to receive help while working through a task. By bringing the focus on the interface widget in question and pressing the F1 key, the user is able to access the context-

sensitive help. A help view will appear at the right side of the Eclipse workbench and display a list of related topics.

Technically, to provide a context sensitive help to the user interfaces in question, one has to integrate a hook in the program which characterizes the help specific context (see also Section 5.3.2). This is done with a help context extension mechanism of the Eclipse help framework which allows to associate a context-sensitive help with a user interface element. The *setHelp* method registered the SWT Control with a *help identifier* which must be explicitly specified by the application developers. This help identifier is associated with related help documents. With the help of this mechanism, Eclipse provides a framework to implement a static help. In addition, the Eclipse framework provides also a dynamic help mechanism. This help mechanism assists pages in integration beyond the ordinary help extension mechanisms. For example, one can integrate dynamic web pages with the help of this concept.

Eclipse also distinguishes between a re-active and a pro-active help mode. In re-active mode the help framework waits for an F1-key press event. In reaction to the occurrence of a F1-key event, the help framework calculates a help identifier, and calls every registered adapter to return a set of help items that implement IHelpResource interface.[80] In the pro-active mode, the Eclipse help framework observes the state of the rich client application and adapts the help text in respect to the observed state. The Eclipse framework allows adapting this functionality by implementing so-called IContextProviders. The help framework will invoke the IContextProvider when the state of the application has been changed, and asks the provider to return a set of help entries. This feature makes it possible to integrate the community feature seamless in the existing framework (see below).

In our case study, we draw on Wiki systems which provide a web service API, because Wikis are widely spread, and allow editing texts in a collaborative manner and the web services allows a smooth integration of the Wiki into the actual context of a situated development. So, the Wiki system was interwoven with traditional context help, so that each user can extend, change or annotate the texts. They can create different local descriptions of purpose, usage, or outcome of a function, and exchange knowledge concerning the appropriation of this function within their local practices.

In order to lower the burden to use CHiC, the access to the Wiki needs to be highly contextualized at the user interface to select those Wiki entries which are associated with the cur-

[80] In order to integrate this new mechanism into the existing framework, the Eclipse framework developers have reused the adapter mechanism of Eclipse (cf. D'Anjou et al., 2005, pp. 476, Pesot, 2008).

rent usage. In Section 5.3 we discussed two strategies for identifying the (boundary) object in question. The temporal strategy uses the history of the applied working-tool for identification; the spatial strategy uses the actual user interface presentation for identification. While Direct Activation relies on a temporal strategy (Wulf and Golombek, 2001), in the design study to CHiC we realized the spatial strategy outlined in Section 5.3.2. This means that we took the actual state of the application as a proxy for the context of use.

By means of the Meta Object Protocol and runtime reflection (Kiczales et al., 1991), we linked Wiki/help pages technically to specific states of the application. From a user's perspective, a Wiki page refers to a function perceived by the users at the interface of the application, and therefore, supports appropriation discourses among communities of users (also addressing diversifying sub-communities).

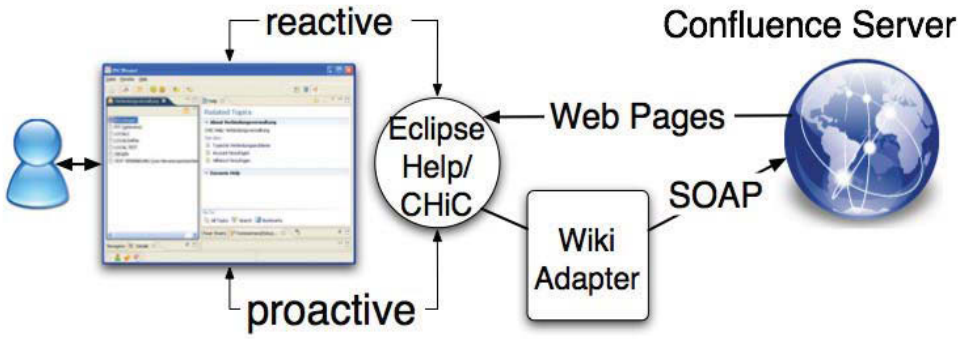

Figure 22 Changing the selected interface element triggers a recalculation of help entries (1). A click on one of the help entries opens the Wiki page via the internal web browser (2).

The idea of the design study was to provide a use experience, where the user first selects the object in question, and then presses F1 to open the corresponding help/wiki page (see Figure 22). In this manner, the software application offers a built-in communication channel between users, and therefore acts as a boundary object for contextualizing discussion among users.

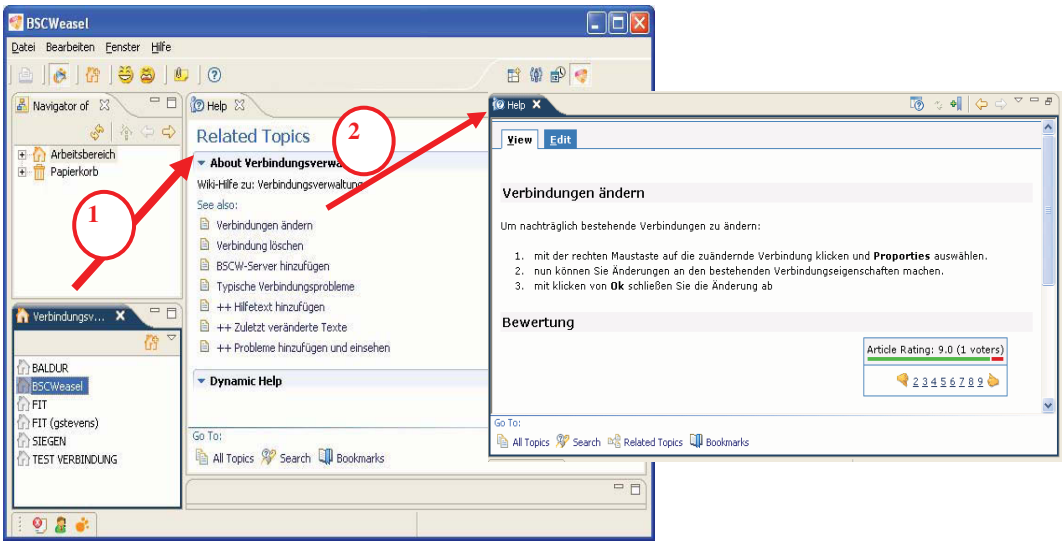

Figure 23 Realization of the general parts of the CHiC architecture

The realization of the three modules of the CHiC concept (see Figure 23) uses the help features provided by Help Framework (see D'Anjou et al., 2005, Chap. 22), and the Wiki features provided by Atlassian Confluence Wiki System (cf. Ebersbach et al., 2007, chap 24).

The provision of a cooperative space is mainly realized with the means provided by the Confluence system. The integration into the local context is to a large extent realized with the means provided by Help Framework which benefits from the feature of the framework that it extends dynamically a re-active and a pro-active help, by writing a sub-class which implements an IHelpResource -adapter as well as sub-class that implements IContextProvider –providers (see above). We use this feature to implement the different parts of the CHiC concept that reach a smooth integration into the ordinary help of an application. This means the AIM module was implemented by writing glue code, which allows presenting social help that is given by the CHBS in the local use context.

The implementation of glue code mainly consists of two functions:

1. map the help identifier to the corresponding place in the CHBS,
2. the adaptor transforms the CHBS format into the format that is needed by Eclipse.

For that purpose an own help item class was implemented that subtypes the interface IHelpResource. The adapter returns help items which deliver the subject labels of help texts, and the URLs of the corresponding Wiki pages. The subject labels of help items are displayed as links in the help window of Eclipse. The effect of the AIM module is that when a user clicks on the label, Eclipse opens the internal web browser and loads the associated web page (see Figure 23). This increases the familiarity of the CHiC extension with the advantage that in the conducted usability studies (see Section 6.4), we do not observe any

usability problems using the CHiC system. However, the familiarity also prevents some users from seeing the new social quality of the enhanced help system.

The AIM module was implemented with the help of an own context provider that calculates an identifier which can be used to mediate between the local context serving as an expressive boundary object, and the CHBS serving as a social boundary object. The context identifier extends the interface of the IContextProvider, and gets invoked by the Eclipse framework whenever the state of the application has changed. The implementation of context provider consists mainly in the calculation of a context identifier. In a wicked situation, the function of the identifier is to interweave an appropriate context-specific EUD environment into the actual use context. Therefore the calculation of the identifier should rely on an interweaving strategy as elaborated in Section 5.3. In the design study, the implementations of the context provider are rooted in the spatial heuristic outlined in Section 5.3.2.

The CBHS module was realized by integrating the Atlassian Confluence Wiki[81] as it provides a commenting function, several notification mechanisms such as mail, RSS, and the recently changed pages. Moreover, it provides a well defined Web Service API. A more detailed description of technical realization of the system is given in Stevens and Wiedenhöfer (2006) and Wiedenhöfer (2006).

This realized approach differs in two dimensions from the revised conception of the Appropriation Infrastructure presented in Section 5.4. Firstly, it restricts the collaborative EUD activities among users to the aspect of changing the interpretation of the material artifact, neglecting the other EUD options outlined in Section 5.1. Secondly, the design only supports reflection in a public space, neglecting the other rooms conceptually outlined in Section 5.2. Despite these limitations, the realization of CHiC provides a proof of the concept with respect to the question of how to interweave the social dimension of the boundary object into the use context, based on a spatial strategy elaborated in Section 5.3.2.

6.3 Collaboration between Users and Developers

The goal of the Appropriation Infrastructure is to bridge the fragmentation of distributed work by providing communication channels between consumption and production spheres. The initial version of the Appropriation Infrastructure system implements this kind of communication by integrating a professional requirements tracking system into the BSCWeasel application, and have equipped it with a specific interface for non-professional end users.

[81] http://www.atlassian.com/software/confluence/

As mentioned the implemented version differs from the idealized architecture outlined in Section 5.2 in two dimensions. Firstly unfortunately the design splits the reflection about usages issues from the reflection about design issues although both are related in the evolution of the artifact as a dialectic unity. The implemented solution neglects especially the evolutionary character of situated development. Secondly, the actual implementation also does not support all kinds of EUD practices outlined in Section 5.2, especially it do not offer appropriate rooms for self-organized groups. Additionally, initially our design efforts focus supports reflection in a public space. Only through the ongoing formative evaluation (which is part of applied research approach of the reflective technology development outlined Section 1.2) we becoming aware of the problem of lacking spaces for personal reflection and we changed the design in this respect.

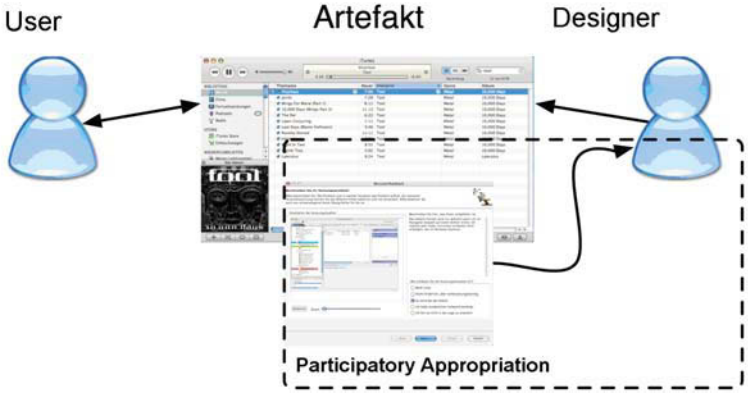

Figure 24 Integrating feedback mechanisms in the use context to support Participatory Appropriation (adapted figure from Draxler, 2007, p. 12).

Apart from this limitation, the realization presents a proof of the concept of how to support the designer participation in the appropriation processes by integrating feedback tools into the use context (see Figure 24). Nichols et al.(2003) also spoke in this context about end-user participation in post-deployment phase, as user and designer interact in a phase in the software life cycle where the product is deployed by the client. However in the age of 'perpetual beta' after a release is for a release so that the term "post" is a bit confusing. Therefore it makes sense to supplement the production perspective expressed by the term "post deployment" by a consumption perspective in talking about appropriation-grounded participation. A first classification of the differences of appropriation-grounded participation approaches has been developed by Stevens and Draxler (2006). Later on, Draxler .

conducted a survey of existing tools that can be used to support a appropriation-grounded participation. In this survey, he distinguishes three different types of tools: *external*, *internal* and *hybrid solutions* (see Figure 25).

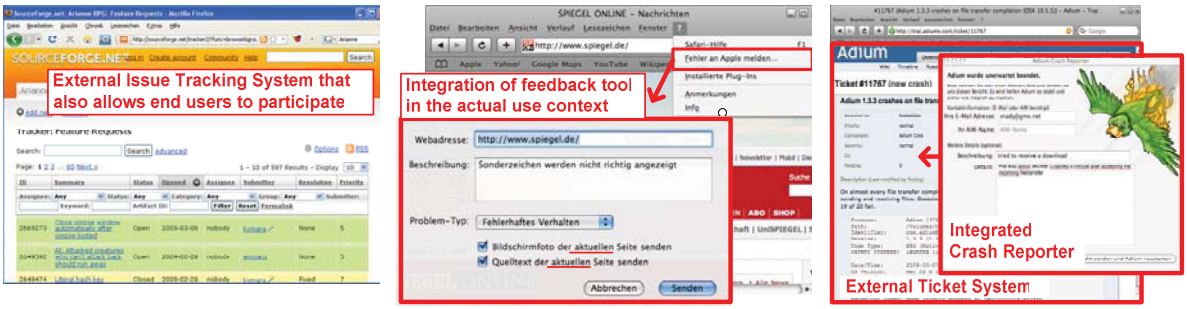

Figure 25 Tools used for appropriation-grounded participation: The issue tracking system of Sourceforge.net (left) provides an external tool for end users to participate in design discourses. Apple Safari integrates crash reporting tools (middle) that allow the end user to give feedback. Adium (right) provides a hybrid solution that connects an internal crash-reporting tool with an external, publicly available ticket system (examples taken from Draxler, 2007).

The specific characteristic of external tools is that they are providing an environment to support the design of an artifact, but they are not software-technically connected with the product. Often independent issue tracking systems are used for this purpose (see Figure 25, left). They are database systems which maintain lists of issues. An issue is a referenceable item in the overall development process, which presents an independent, but interdependent part of a development trace. Bug-tracking systems as well as help desk systems are both examples of issue tracking systems. Although they address two different target groups, they are more or less identical from a functional point of view: Bug-tracking systems are often used to manage design issues, while help desk systems are often used as customer issues. This means the target groups of bug-tracking systems are technicians, which use the system to create, update, and resolve development. Through this kind of use, bug-tracking systems often become a solution-oriented knowledge base containing the actual state of the development process and design rationales from a technical point of view.

In contrast, the target groups of help desk systems are marketing departments. They use it to create, update, and resolve reported customer issues. The help desk systems become a needs-oriented knowledge base containing information on each customer, resolutions to common problems, and other such data. From a EUD perspective, interesting forms of help desk systems are ticketing systems, which have their own user front end, which allows users to create, to manage and track issues. In the commercial context, users typically have no access to the complete knowledge base.

This is different in the Open Source context. Typically not just the source code is open, but - as shown in the Eclipse example presented in Section 1.1 – the development is carry out in

an open manner. In particular, the whole knowledge base stored in issue-tracking systems publicly available, and allows everybody to contribute to this knowledge base.

Issue tracking systems may be the most important external tools for supporting appropriation-grounded participation, but also forum software or newsgroups are used as tools for integrating the user perspective in the design context. Additionally, end users use this collaborative software in combination with other external tools, like graphic editors to express their design ideas (cf. Nichols and Twidale, 2006).

The advantage of external tools is their low cost and their flexibility to use them in a different context. However, the missing software-technical connection to the material artifact that becomes an inquiry and design object in situated development results in disadvantages on two dimensions. The first dimension is the usability aspect; because of the missing connection, in a wicked situation, an extra overhead is needed to become aware of and switch to the external tools. The second dimension concerns the missing context awareness. Because of the missing connection, external tools have no opportunity to support context-aware collaborative EUD by means of a program-based inspection of the use context where a wicked situation has its constitutive center.

Internal tools for appropriation-grounded participation are integrated in the deployed artifact. This allows a close software-technical connection to the context of a wicked situation, where the artifact becomes present-at-hand. This has the advantage that users must not leave the application when they want to switch from use mode to the use reflection mode. Instead, the collaborative EUD environment can be directly activated from the use context. In addition, the internal tool can inspect the state of the artifact, and collect data about the actual use context. The collected data can be attached to the issue created by the user in order to make the specific local context more transparent for a de-contextualized, collaborative design-discourse. In addition, the inspection of the actual use context can also be used by heuristic algorithmic strategies to identify related issues in the public knowledge base. The detection of similarities in the usage problems and design ideas helps support the management of the various interdependent development traces, and also supports the uncovering of potential communities of shared interest.

Today, internal tools for appropriation-grounded feedback are typically crash reporting tools. An example of a crash reporting tool is given in Figure 25, middle. It presents the feedback tool Apple has integrated in its Safari browser. However, these tools are often limited with respect to the means of expression of design ideas. For example, some crash reporting tools only provide the option of sending the automatically collected data, or not

sending it. In addition, the users often have no access to the knowledge base where their contributions are stored and the design process is organized.
Hybrid solutions consist of an external and an internal component. However, the integration is often limited to a menu item that allows to access the external tool directly from the use context, and does not make use of the actual state of the application. A more sophisticated solution is the combination of a crash reporter built in the product *Adium* and a public ticket system (see Figure 25, right). With the help of the internal crash reporter, data of the use context will be automatically gathered, and the user has the option to add this data to the issue that she can create with the help of the internal tool. After creating an issue, the user gets a unique number (ticket) to track the issue on the public ticket system.

In the BSCWeasel project, we chose a hybrid solution to bridge the use and the design sphere. One reason for deploying an existing external tool was that with regard to designer needs, we wished to prevent an additional knowledge base, and therefore integrated user participation into the existing design discourse infrastructure. With the help of this design decision, we tried to minimize the administration overhead to manage the user feedback together and coordinate the user participation with the other activities in the software development process. Nevertheless, we tried to lower the burden for the end user by integrating this communication channel in the use context. Therefore we developed a hybrid solution called Participatory Design in Use (PaDU) that shares many aspects with Adium's hybrid solution, combining an external requirements tracking system with an internal incident reporting tool.
The external part of PaDU was realized with the help of JIRA.[82] JIRA is a professional, web-based issue tracking system that supports the interaction among developers. JIRA allows saving requirements in textual form, which can be annotated with attachments, e.g. log files or screenshots. Users of JIRA can discuss these requirements, prioritize and vote for them. A configurable workflow allows processing these requirements within the team of developers. The functionality of JIRA can be used via a web-based interface or it can be integrated into 3rd party products via the Web Service API.
The internal part of PaDU was realized as Eclipse plugin that can be integrated in any Eclipse RCP-based application. We added this plugin into the default set of BSCWeasel

[82] More precisely, we just use an off-the-shelf JIRA system, and wrote a client extension (see below) which allows to integrate the user participation into an existing developer infrastructure.

components, so that the PaDU functionality was directly accessible from the BSCWeasel user interface. The plugin provides specific views of the issue tracking system.

Technologically, we drew on the Web Service API of the requirements tracking system, to integrate the JIRA functionality into the BSCWeasel application. Technically, PaDU packages JIRA's Web Service API, and makes it available for Eclipse RCP applications. If a requirement is submitted to JIRA or information is retrieved from JIRA, PaDU will carry it out via the Web Service. To lower the barriers for users, PaDU uses Eclipse's integrated web browser. When the user wants to see detailed information about his contribution, PaDU will open the corresponding web page.

In order to enable contribution to the design process directly from the BSCWeasel user interface, PaDU integrates two buttons of the application's toolbar (see Figure 26).

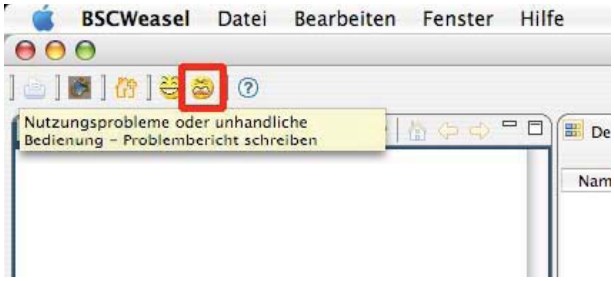

Figure 26 PaDU's access point is in the button bar which activates a channel to communicate with the public requirement tracking system

The buttons help distinguishing between critical incidents (a subjective breakdown of tool usage) and use innovations (a new way of using existing functionality or a new idea for interesting functionality). These buttons are always visible, and they are used as access points to document problems or suggest new design ideas.

When a user presses one of these buttons, a multi-page dialogue window appears. In the first version of PaDU, for the feedback dialogue we adapted the critical incident dialogue which Castillo (1997) used in this master's thesis to realize a tool for remote usability testing (see also Hartson et al., 1996).

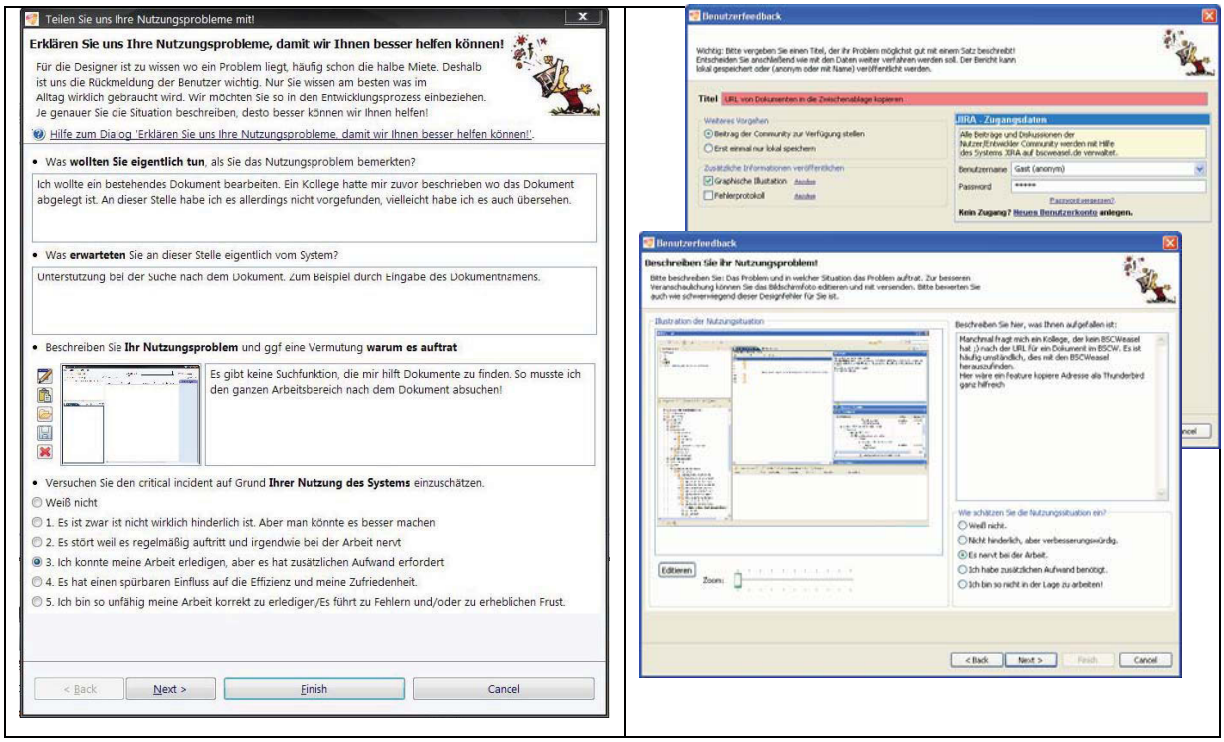

Figure 27 First version of the PaDU dialog (left) based on the work of Castillo (1997) and the revised version (right) based on the theoretic reflection of the initial structure of expressive boundary object.

The original idea of Hartson and Castillo was that users report a critical incident in reaction to unexpected system behavior. Based on this, Castillo (1997) designed a guided dialogue, structured by a set of questions which have to be answered by the user.[83] In the initial design, PaDU used a marginally modified version of Castillo's dialogue (see Figure 27, left). However, in the formative evaluation of the PaDU, we become aware that the differences between the PaDU conception, and the ideas behind the remote usability approach suggested by Hartson et al. (1996) also have consequences for the dialogue design. The work of Hartson et al. (1996) is based on laboratory experiments with students, which received an initial training in writing appropriate critical incident reports. In contrast, PaDU are integrated in BSCWeasel as a daily work tool, and should be used ''in the wild'' by ordinary users without any training. In informal talks, we received the feedback that the questions are

[83] Castillo (1997, pp. 155) used a critical incident report dialog, where the user was instructed to answer eight questions in the in following order: 1. Explain *what you were trying to do* when the critical incident occurred. 2. Describe *what you expected the system to do just before* the critical incident occurred. 3. In as much detail as possible, *describe the critical incident* that occurred, and why you think it happened. 4. Describe *what you did to get out* of the critical incident. Were you *able to recover* from the critical incident (Yes/No)? 5. Are you able to reproduce the critical incident, making it happen again (Yes/No)? 6. Indicate in your option *the severity of this critical incident*. (1-minor … 5-critical problem). 7. What *suggestions do you have to fix* the critical incident? 8. You can also include other comments, feature requests, or suggestions. 9. Enter the *location (or URL)* of the screen where you found the problem.

confusing, and their order is confusing as well. In reaction to this, we reduced the dialogue to one single question. This question based on our theoretical reflection that the moment of attention characterizes the initial structure of the expressive boundary object. So we reduced to core question of an initial wicked situation, namely “what has attracted your attention?”

The advantage of this dialogue is that it leaves the question open, if attention was initially raised by a malfunction or by an actual experience that is triggered by an innovative idea, or anything else. Moreover, the intention of the dialog was not to attain a complete report of the use situation, but to create an initial event of a user-designer collaboration that starts a development trace. In creating a social practice between designer and user, in further development of the trace any open question can be clarified if needed.

Another issue was the design of appropriate means to express design issues. Here, one core element in the concept of direct manipulation is to emphasize the primacy of sensual reasoning over cognitive reasoning. The realization of PaDU takes up this aspect in such a way that beyond purely textual descriptions of the design ideas, we integrate features which allow for ostensive and deictic references to the software artifact in order to clarify design ideas. We have, for instance, extended the dialogue window to enable users to add screenshots, annotate them textually or graphically, and attach own sketches. PaDU automatically takes a snapshot of the current state of the BSCWeasel interface at the moment it is activated. At a prominent place in the feedback dialogue, the screenshot was integrated with an opportunity to edit the screenshot (see Figure 27, left). Editing the screenshot opens an integrated drawing tool. In opposite to other drawing tools, the design have reduced the functions to the core features that are needed to express a design idea graphically (see Figure 27).

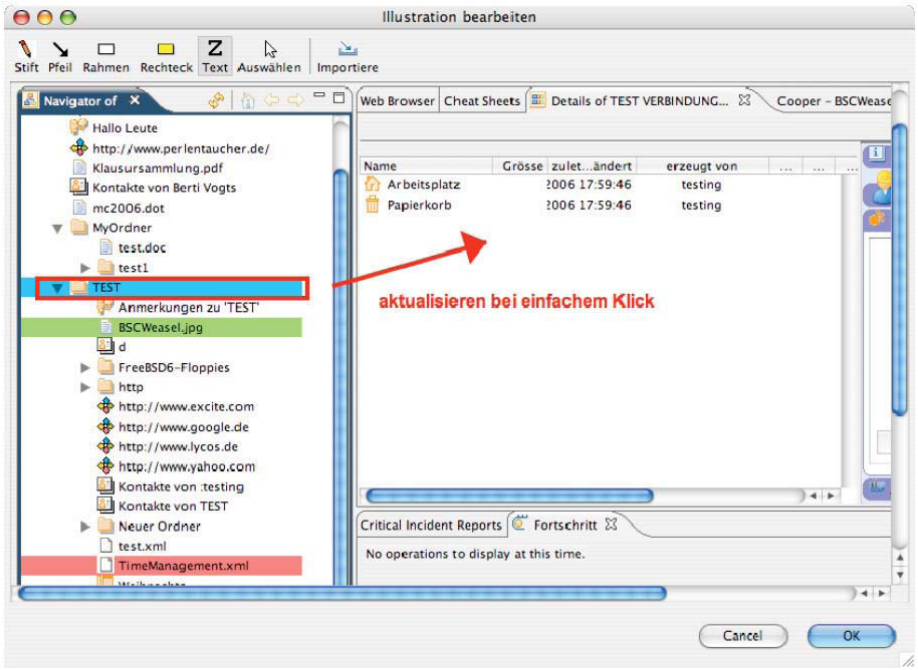

Figure 28 Integrated snapshot annotation tool to support the scribbling of design ideas

In the formative evaluation of the PaDU design conception, one core aspect from the user's point of view is the transparency of the underlying development process. Several users mentioned that they do not use feedback tools in commercial products, because they do not see what happens with their comments, and in which way this will influence the upcoming design. At the same time, from a normative stance, we understand design to be a communicative process, which needs to be transparent to those who want to participate. This stance distinguishes our approach for instance from the concept of remote evaluation promoted by Hartson et al. (1996). In their work, end users are limited to delivering information about shortcomings in design. However, users' participation in design-related discussions of these shortcomings is not technically supported.

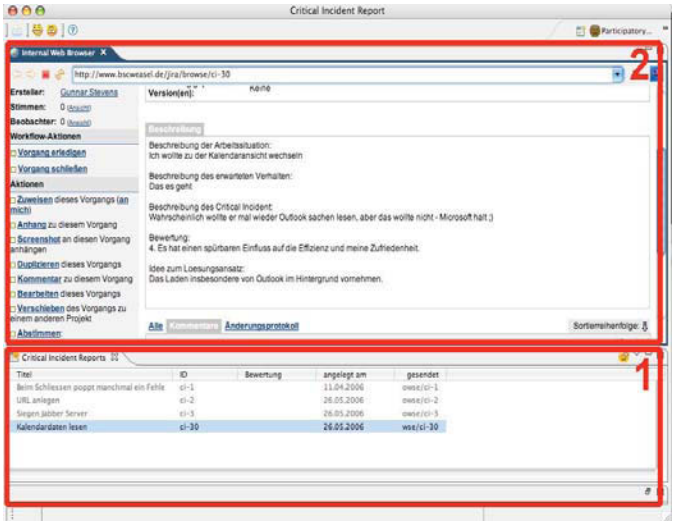

Figure 29 PaDU perspective integrated in the Eclipse RCP: (1) list of all personal issues (2) corresponding issue on the public issue tracking system

This normative stance was reflected in the design of PaDU in such a way that users and designers were granted similar rights with regard to inspecting the requirements database and adding comments. To support users in becoming familiar with the web interface, and to increase their awareness of the design process, we chose a similar design conception as the hybrid solution of Adium mentioned above.

Finishing the contribution made by the feedback dialogue calls a web service method that creates an issue in the public issue tracking system. This call delivers the issue identifier or *ticket number*. The user did not only get a notification with his ticket number, but PaDU adds this ticket number in a local database and switches to a new Eclipse perspective, which shows a list of all local stores issue items (see Figure 29 (1)), as well as an embedded browser that displays the web page of contribution as it is stored in the publicly available issue tracking systems (see Figure 29 (2)). With the help of the list, the users can see all of their ideas, and it is also possible to import interesting issues from other persons. A double click on the published design ideas opens the web browser, and shows the corresponding web page in the requirement tracking system. The web page shows the contribution in detail, as well as the state of the contribution in the overall design process, and discussions and comments added in reaction to the contribution. The web page also allows users to add comments and additional data. However, one drawback of the current implementation is that there is only email notification, while no notification service is integrated into the application itself. This has two disadvantages: Firstly, it disrupts the close connection between design and use context. Secondly, it does not allow informing users who made anonymous contributions.

The initial version of the PaDU dialogue has another drawback in that the user has only the one option of sending his design reflections to the public issue tracking system, or to cancel the entire action. However, in our formative evolution, some users mentioned during informal talks that they were missing a feature that allows them to reflect personally on their BSCWeasel experience, before sending a report on the public space. Therefore, in a further version we added the opportunity to store and edit reports locally, and to send them to the public space at later stage of the situated development trace. This feature allows to write a design suggestion for one's own purpose, before it is published within the public community. However, the feature to offer rooms where a self-organized group can work on a development trace cooperatively is still missing.

The PaDU system did not only affect the way users participate in the design process, but also the work practice of the designers. Designers can deal with the contributions of the users in the same way they do with any other requirements documented in the system. They can discuss these requirements, prioritize them and vote for them. To offer accountability with regard to their inputs, users can see all activities that happen in the requirements tracking system. Via their interface, users can track the state of their contributions. They are informed via email in case someone comments on their input. They can also set up links to other entries in order to be informed about the state of their procedure. Additionally, designers can send a direct email to a user to clarify open issues. However, the discourse culture which emerged in the BSCWeasel project was slightly different. Instead of writing an email, questions to a contributor were attached as a comment. The contributor received an email containing this comment and had the option to answer to the email by adding a new comment. As a result, a public discourse around certain requirements emerged.

A more detailed description of technical realization of the system is given in Stevens and Draxler (2006) and Draxler (2007)..

This realized approach differs from the revised conception of the Appropriation Infrastructure presented in Section 5.4 as it only provide rooms for private and public discourse. In addition the PaDU is separated from tailoring functions or the community help feature provided in CHiC. In particular, it does not make use of the context sensitive interweaving strategy implemented by the CHiC system. Despite these limitations, the realization of PaDU provides a proof of the concept with respect to the question of how to integrate cooperation features in the software artifact that improve the mediation of consumption and production among the product community.

6.4 Evaluation

With the implementation of CHiC conception and PaDU conception, two different aspects of the Appropriation Infrastructure have been prototypical realized. Technically, the prototypical implementation of CHiC as well as PaDU is realized as a set of Eclipse plug-ins which are running on the top of the Eclipse RCP. This allows to integrate in parallel both aspects of an Appropriation Infrastructure in any Eclipse RCP application. The opportunity was used to evaluate the idea of the Appropriation Infrastructure in practice with the help of the BSCWeasel project.

In May 2005, an initial version of BSCWeasel was used by the developers and their student team. Later versions were announced to the research group at the university (about 15 members) and to two groups at a research institute in applied computer science (about 15 researchers), 100 km away from the university.

All researchers were basically familiar with BSCW, though the system was applied to rather different degrees. The appropriation process of BSCWeasel was analyzed via the discussion threads provided by PaDU and CHIC. Moreover, observations and informal interviews were carried out to explore the appropriation of BSCWeasel further on. Additionally, two studies were conducted based on the ISO 9241-10/12 standards, to improve the usability of the application. The first study was carried out in April 2005 with nine users. It focused on the basic functionality of BSCWeasel. In January 2006, a second study with six users looked particularly into the usability of the CHiC and PaDU functionality. For that reason a BSCWeasel configuration was deployed, where the CHiC and the PaDU plugins are integrated by default. Figure 30 illustrates the Eclipse plug-in assembly of this deployed BSCWeasel version. In respect to an ideal architecture described in section, the main deviation of the realized architecture is that PaDU and CHiC are completely separated. In particular, a refactoring of the architecture should merge the PaDU UI and the CHiC AIM components into a unique AUEF module as described in Section 5.4 In addition a refactoring should integrate the store and sharing feature of the PaDU/JIRA and the CHiC/Confluence binding in a unique RCF module as described in Section 5.4.

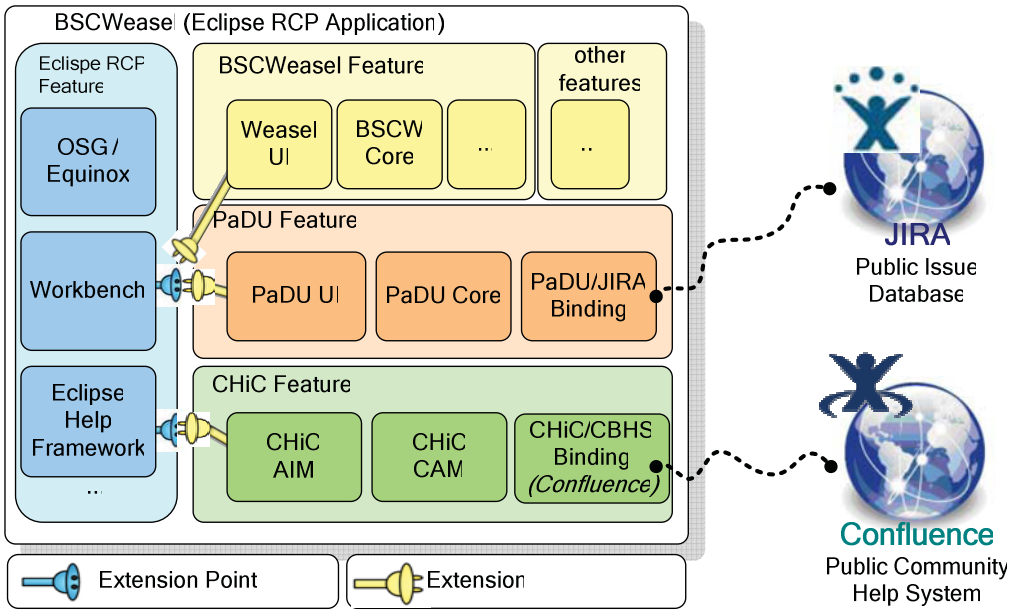

Figure 30 Eclipse plugin assembly of the deployed BSCWeasel configuration that was used in the evaluation

With regard to the appropriation of BSCWeasel at the university and the research institute, we know about 10 regular users. They were intense users of BSCW before and identified specific BSCWeasel functions to incorporate into their own practice. The individual "killer" functions were not part of the BSCW thin client, and covered a wide range of functionality. Some of them were requested via PaDU – like the option to download more than one file or complete folder structures, or a synchronized view on local and remote directory structures. Other functions were communicated directly towards the team of developers.

About half of the BSCWeasel users have made use of PaDU. From September 2005 to July 2007, 130 design requirements were expressed via PaDU. Due to the relatively small number of active users, the design team was rather responsive towards their suggestions. About 50% of these proposals were implemented.

In evaluating our experiences, we will focus on two main issues. First, we will investigate the impact of the appropriation infrastructure on the design process. Second, we will look into the relations and interferences among the different functions of the appropriation infrastructure.

6.4.1 Empirical findings: Revision of the initial design conception

As mentioned above, when starting the BSCWeasel project's original conception of the Appropriation Infrastructure, it was assumed that CHiC and PaDU address two important, but independent moments in the appropriation of technology. However, when integrating the different parts of the appropriation infrastructure and studying them simultaneously, we be-

came aware of interference. The lacking integration of users' communication channels with those channels between users and designers created problems. The segregation of the different appropriation support functionalities – such as help, adaptation, or requirements articulation – seems to be dysfunctional.

We observed that CHiC was mainly used as a traditional help system, with only little discussions among users going on. It seems that CHiC and PaDU cannibalized each other, since both could be applied when BSCWeasel was not readily available. This fact became obvious in the second usability study. An interviewee stated that he is occasionally uncertain whether to address other users or rather the developers. He had a problem in connecting the BSCWeasel client with the BSCW server. Reflecting on his problem, he was not sure whether it was caused by bad design or inappropriate use. So he could not decide easily whether to discuss his problem in PaDU or CHiC. In another case, a user explained that she put a question into PaDU but later cancelled it. She was not sure whether this issue was just her personal problem, ("just not knowing enough about the system"), or if the issue was more generally relevant for the design of BSCWeasel. This case describe the same structural dilemma as we analysis in Section 4.3, that in a actual wicked situation 'function does not exist' and 'function not found' presents two objectively given modalities, so that is difficult for the user to choose the right communication feature. These findings seem to indicate a need for a deeper integration of PaDU and CHiC.

Another example for lacking integration is the gap between flexibilization at the level of the user interface when compared to the level of the component structure of the application, and its missing integration into a communication infrastructure. Eclipse's GUI concept offers an elegant solution for the composition of views[84] compared to user interfaces of web-based clients augmented by applets. All interface elements can be integrated into a combined view, called perspective. We observed that this feature was applied by the users to individualize their user interface. However, Eclipse still suffers from the fact that the interface layer of a user-centric composition is not connected to the underlying component structure. Thus, the underlying structure is not visible, and cannot be directly explored and adopted from the user interface. Obviously, lacking co-referentiality (cf. de Souza et al., 2001) between software structure and user interface leads to confusion, and does not support users in understanding the link between the user interface and the underlying software architecture.

[84] A view is a user interface that presents a kind of application unit.

As a result, users may develop a mental model which diverges strongly from the software architecture. It leads specifically to problems when applications, such as Eclipse IDE or BSCWeasel, are composed by hundreds of components provided by different vendors.

During our usability study, we found an example for these phenomena. It turned out that users assumed that our chat tool (a 3rd party component) and the BSCW system where tightly coupled because the interface elements were integrated. In another case, we observed an Eclipse IDE user who had problems in finding out which vendor was responsible for a specific view which he had added to his user interface. He was looking for more information about the object in question. Moreover, Eclipse suffers from lacking integration of the component management features into a community-oriented communication infrastructure. The Eclipse community is beginning to become aware of this problem. In particular, some commercial companies like Innoopract have started to extend Eclipse with a component repository service with thousand of plug-ins. They support end users to assemble their personal Eclipse configuration from the repository in an easy way. In the meantime we have started cooperation with this firm as a part of the CoEUD research project. In cooperation with this firm my colleague has started to investigate new forms of IT management beyond traditional centralized provisioning strategies. In particular, we explore opportunities to enhanced traditional solution by features that support a grassroots diffusion of composition and tailored artifacts (cf. Stevens et al., 2007, Draxler et al., 2008a, Draxler et al., 2008b, Draxler et al., 2009).

At this point I want to make a methodological remark to illustrate the abductive stance of my thesis and the parallelization of working on the artifact, working with the artifact and working on the concepts outlined in Section 1.2: The observation of the interference of the different elements of the realized Appropriation Infrastructure system was one of the surprising facts that motivated to reflect on the phenomena of formation of the artifact as an element of social practice. In particular, the empirical observation of the appropriation of the implemented system, and the theoretical conception outlined in Chapter 4 are not connected by inductive, but by an abductive reasoning in the sense of Peirce: The case study of the BSCWeasel has not collected empirical facts to validate or falsify the theoretical concept of the artifact as a dialectic unity of material and meaningful construction; this is subject to continuous development. Instead, the theoretical concept is a possible explanation of the observed case. The concepts provided the analytical point of view on where interference in using the different features of the realized Appropriation Infrastructure did not present a surprising fact, but an expected result.

The practical experience gained from the BSCWeasel case is taken up in the idealized modular architecture presented in Section 5.4. The implemented prototypes were a first step to realize the Appropriation Infrastructure as a holistic EUD approach. Nevertheless, a major refactoring of the two separated implementations of CHiC and PaDU is needed in order to bring the implemented architecture closer to the idealized one of Section 5.4. Future research will be required to solve technical and organizational problems as well as evaluate the conception in practice.

6.4.2 Participatory Appropriation: Grounding Design in Practice

One idea of Appropriation Infrastructure is to bridge consumption and production among product communities. This is a similar concern as the one of Participatory Design. However, while traditionally Participatory Design is interested in what happens when users participate in the design context, we are also interested in question what happens when designers participate in the use context. Therefore, this section studies the use of the Appropriation Infrastructure approach not from the perspective of the consumption sphere (as in the previous section), but from the perspective of the production sphere. In order to emphasize the parallels with the Participatory Design approach, but also to highlight the inverse direction of the research interest, this section studies the use of the infrastructure from the analytical lens of 'participatory' appropriation, which allows designers a closer connection with the context of use.

One of the important results of the case study was that after the roll-out of PaDU, the designers got more feedback from users. Since PaDU items were stored in the Bug Tracking System, the feedback was more systematic and easier to handle, and became an integral part of the coordination work carried out by the designers.

PaDU is mainly used by users to make designers aware of a usability problem and/or feature request, however discussions among designers and users happened only rarely. This may be due to the fact that PaDU does not disclose the user's identity. However, we found frequent instances where contributions made in PaDU triggered a reflection process within the design team, e.g. discussing design alternatives related to a concrete user experience. Sometimes designers react to a user comment, when requirements expressed by the users were not clear (e.g. a designer wrote: "Well, technically this is a little thing [to implement the feature request]. However, for the moment is not yet clear to me how you would like to use it") or different solutions were possible, (e.g. asking which of different options to implement an "open file with …" feature would be needed).

Most of the contributions made by the users referred to cases in which they were able to accomplish their task, often by means of a workaround, but wanted a better support from BSCWeasel. The snapshot annotation tool was typically used to point to the referenced area in the user interface. The suggested re-designs often address incremental improvements that either enables more control or efficiency to their work. For example, with regard to the upload function, a user made the following proposal: “It would be a nice thing to know the data volume ahead of an upload. In this case one would know how long it takes and whether there is sufficient space available”. Analyzing the contributions made via PaDU, we found few design requirements which went far beyond the given functionality. Most of the suggestions were rooted in practical experiences using BSCWeasel in the users’ daily work.

In summary, accessing PaDU directly from their context of use seems to stimulate users to focus on readily available technology when contributing. It seems to result in incremental rather than highly innovative suggestions for redesign. However, these contributions, based on practical experience, had a considerable impact on the design process.

Especially from a designer perspective to participate on the appropriation of the product provides a notable means to decrease the symmetry of ignorance. One of the developers came up with the following observation: “If programming is understood as theory building (Naur, 1985), PaDU helps making it a ‘grounded theory’”. Nevertheless, PaDU should be perceived as an additional instrument to improve distributed, continuous Participatory Design, not as a replacement for traditional, creativity oriented Participatory Design instruments like Future workshops that foster a broader perspective on the own situation. This means in future we should also explore means for blended Participatory Design.

7 Conclusion

> „Now the principle of sociality that I am attempting to enunciate is that in the present within which emergent change takes place the emergent object belongs to different systems in its passage from the old to the new because of its systematic relationship with other structures, possesses the characters it has because of its membership in these different systems" (Mead, 2002, p. 87).

Innovation becomes the sine qua non in the software industry. In my thesis, I propose the concept of Appropriation Infrastructure which studies the topic of innovation development from a local perspective that is rooted in situated action (Suchman, 1987). Due to the distributed nature of software development not just the formation but also the mediation of innovation as an emergent object becomes a relevant research topic. When conceptualizing Appropriation Infrastructure, the challenge was to answer the question of how the specific qualities of the digital material can be used to support the distributed evolution of software.

Studying the specific qualities of software, we can first of all state that there is a dramatic reduction in the incremental costs as well as in the costs of incremental changes. Thus, software becomes a mass-product that evolves in general, as well as an artifact that evolves in the local context. In Chapter 2, I have discussed how this trend is reflected in research. In the area of Software Engineering, I have identified two different research fields that focus on the evolvability of software in a different manner. The first field focuses on the flexibilization of software production, elaborating on approaches like Agile Software Development (Beck, 1999) and flexible production ecosystems (Messerschmitt and Szyperski, 2004). The second field deals with the flexibilization of software products, elaborating on approaches such as Component Based Software Development (Szyperski, 2002). EUD research (Wulf et al., 2008, Stevens and Wulf, 2002) helps to adapt general flexibilization approaches to the special needs of end users. In addition, research on the appropriation of technology (Orlikowski, 2000, Pipek, 2005a, Törpel et al., 2003) has demonstrated that practices and artifacts are co-evolutionary entities. In particular, IS research on appropriation has suggested that artifacts need not only technological, but also interpretative flexibility.

The survey on the different approaches dealing with evolving software artifacts has helped to line out the individual facets of my research topic in supporting continuous software development. In particular, it becomes evident that a conceptual framework which intends to cope with the complex nature of the topic must integrate at least the three following aspects:

- software evolution in the dialectics of existing and emerging,
- software evolution in the dialectics of material and meaningful construction, and
- software evolution in the dialectics of particular and general development traces.

However, in the literature on evolutionary software there is a lack of appropriate concepts for studying these different dialectics in their mutual relations. This is why I started this interdisciplinary research endeavor. In particular, I explored the philosophical origins of evolutionary thinking in more depth, and found in the Romantic idea of expression a highly relevant concept for IS research. I interpret expression as a structural model of the constitutive condition for the appropriation and realization of innovation. In this notion, the old concept gains contemporary interest, if we retain the essentials of the Romantic expression, but transform it so that the concept can be applied to the current practices of producing and consuming digital goods.

The emphatic appropriation concept of Marx presents an exemplary case for such a transformation. In Chapter 3, I have demonstrated how to keep the basic pattern, but nevertheless generalize the idea of expression so that it can be applied to study modern forms of fragmentation in distributed production environments (cf. Honneth, 1995, Taylor, 1977). Also, the emancipatory, but partly elitist ideal of self-expression was maintained by Marx as a normative category when elaborating on the objectification of labor (Vergegenständlichung von Arbeit), albeit in a democratized version.

The structural model of expression provides a dynamic view to uncover the role of products in mediating and accumulating socio-historical formations. The formation is understood to be of a dialectics between the appropriation (Aneignung) of nature and the realization (Verwirklichung) of the human in nature. This formation does not just describe a process of change, but is inevitably connected with ambitions regarding the progressive development of individuals and humanity. The rationality of this process is rooted in the human ability to step out of the nexus of immediate action, thereby creating a reflective present where subject and object are constituted as abstractions.

The Marxian conception denies the existence of a Descartesian subject that is separate from its material nature and able to discover the material world from this empirically void perspective. In contrast to the Descartesian model, Marx posits that subject and object did not exist from the beginning, but only as the result of an appropriation process. More precisely, subjects and objects are constituted in the reflection on the embodied action which expresses our practical familiarity with the everyday world. A similar topic can be found in

the Pragmatist thinking of Peirce, Dewey, Mead and - following Westphal (2003) - also in Hegel as the “original pragmatist” (Westphal, 2003, p. 49).

The emphatic concept of appropriation provides orientation with regard to obsolete dualistic debates in contemporary IS regarding the structuration of technology (cf. Orlikowski, 2000, Poole and De Sanctis, 2003, Jones and Karsten, 2008). In this discourse, embodied structure is juxtaposed with the enactment of emergent structure. From the elaborated dialectic view on appropriation, this debate arises around the wrong dichotomy, as appropriation cannot deny the structure of embodied in technology. Instead, this structure presents the material to be appropriated. However, we should not only look backwards, asking what structure was selected by users. We should also look forward, asking what emergent structures are being constructed from the selected material. Moreover, in the human-centered design approach towards Appropriation Infrastructures, I explore appropriation practices from both directions to overcome the ‘tailorability dilemma’ (Stevens et al., 2006) which is encountered by attempts to support emancipatory praxis using a techno-centric EUD ideal (see Section 2.2). It become obvious that appropriation and production work must be mediated not merely to benefit from innovations which emerge in the appropriation practice, but we would also benefit in designing better materials with which to support users in their appropriation work.

Taking the formative element of appropriation seriously, distributed development is not only confronted with the coordination problem of fragmented work (which is typical in CSCW), but also with an epistemic problem of fragmented experience which is underestimated in current research. Looking at these problems through a theoretical lens shaped by the grandfathers of evolutionary thinking (in my case especially Hegel, Marx, Peirce and Mead) also leads to revised interpretations of wicked situations, especially situations of breakdown. Usually, breakdown situations are studied only in a backward looking direction, retrospectively analyzing the causes of the interruption. Looking at them in a forward direction, one gets aware of the innovative potential within situated developments. A related view of wicked situations is sketched by Oevermann’s *crisis* conception (cf. Stevens et al., 2008, Oevermann, 1996, Oevermann, 2001b, Oevermann, 2008b) as well as by Pipek and Syrjänen’s (2006) work on the *point of infrastructure* as being both the result of breakdown of routinized action and the source of innovative practices for overcoming existing obstacles.

This insight about innovative potentiality was one of my motivations for taking wicked situations as the paradigmatic case for elaborating a grounded theory about the work to contribute a situated innovation to a public design discourse.

Following a human-centered design approach, I especially focus on specific features of the immaterial material of software. Guided by the interaction between my theoretical lens and my practical interests, I explored the mediating role of situated artifacts which become present-at-hand in wicked situations. To ascertain the mediation structures embodied in the artifact present-at-hand, in a first step, I adapt Marx's analysis of the medial quality of products as a sensitizing concept. In particular, I reflected about the potential uses of evolutionary software artifacts as mediators in distributed settings of production and consumption. In a second step, the Marxist perspective was combined with a Pragmatist perspective, especially a Peircean view on mediation structures as Thirdness, and a Meadean view on emergence as part of a social present (see Section 1.4.3). The connection between both schools of thinking is created via a dialectic Hegelian view on evolution, and the principle of embodiment.

This combination provides the necessary theoretical equipment for studying mediation instances in which the artifact serves as a boundary object on the way to make a wicked situation accountable across social worlds. The theoretical model interprets wicked situations as creating a place for reflecting on one's own life praxis in its evolution. The appearance of something new describes the spatial dimension, while the inhibition of routinized action describes the temporal dimension of wicked situations. Moreover, wicked situations have an evolutionary structure, where the appearance of a wicked situation marks the starting point of a situated development, where the artifact present-at-hand becomes the object of inquiry and design activities. A temporal end of such a situated development is given by leaving the wickedness in control of the situation (see Dewey's pattern of inquiry, also Section 4.2.2), either because the situated object will be neglected (then the emergent object was ephemeral) or it can be articulated (then the emergent object gains an accountable structure of a situated innovation).

From a practical as well as from a theoretical point of view, the most interesting case is when wicked situations bring forth situated innovations that are of general interest. From a retrospective analysis of such a transition, the constitutive conditions for mediating progressive development can be studied. In Section 1.3, I highlighted that these conditions are generalizability, communicability, and experiencability. This finding re-interprets the common distinction between invention (novelty) and innovation (generality) in terms of the required mediation structures. Regarding the mediation structure itself, I focused in my thesis mainly on the role played by the artifact present-at-hand. In Chapter 4, I have shown that

we can identify three different qualities embodied in the artifact present-at-hand, which refer to the above described constitutive conditions.

In my thesis, I use the terms expressive, social, and political boundary object to characterize these three mediating structures. The outlined structural model supplements Star's boundary object concept with a phenomenological perspective, reconstructing the appropriation of wicked situations. In focusing on the subject making use of boundary objects, I follow a human-centered design approach without neglecting its social dimension.

Analyzing the constitutive relations reveals that the expressive artifact presents the basic form of the structures mediating between (kn)own reality construction and the experience of a foreign, unknown situation. The expressive structure is the lowest limit of mediation beyond which mediation will degenerate in praxis. When the artifact is ready-to-hand, the mediation structure has already degenerated since the relations of subject, object, and mediator have vanished and are subsequently replaced by the unity of routines.

However, in the case it becomes present-at-hand, the mediation structure presents an irreducible contradictory unity, mediating between the existing, but now wicked routines and an unknown experience. This quality describes the lower limit of appropriation where the artifact is given by the reflective present on the one hand, and the embodied action on the other hand.

The conflict between one's own and the foreign perspectives forces a situated development confront an open future, whereby the boundary object in its evolutionary structure becomes the subject of a sequence of qualitative transitions.

The social quality of the boundary object refers to different social worlds that become present in the artifact (see Section 4.3). Through this quality, the artifact serves as boundary object in the sense of Star and Griesemer (1989). It belongs to different social worlds, enabling mediation between these worlds by carrying the different perspectives of different worlds at once. The common ground of the expressive and the social quality of the boundary object is given by Mead's concept of a social present.

The political quality of the artifact as a boundary object refers to the different interests which have to be negotiated in the development of shared artifacts (see Section 4.4). These interests are not static, but evolve in the dialectics of appropriation and realization. In the qualitative transition, different social practices become present in the artifact. In these mediated social practices, the artifact becomes itself an object of common activities that have to be coordinated and negotiated on the basis of roles (as anticipated behavior and interest). Moreover, the self does not (always) reflect from the own perspective, but provides a kind

of substitutional reflection from the anticipated perspective of a generalized other and in taking over this role, the own and the general interest on common activities can be reflected.

For this case, a common ground between the social and the political qualities of the boundary object are provided by Mead's concepts of a social present, his considerations on the realities of perspectives, and the role of the generalized other. The artifact present-at-hand is a boundary object in a social practice which carries the different perspectives of this practice, thereby enabling the genesis of the role of the generalized other for this particular case.

With respect to the social practice that arises in the boundary object, I distinguished, following Oevermann, between collectivized or a socialized ones. In case the boundary object presents a collectivized practice (vergemeinschaftete Praxis), bringing up the own perspective is ideally always legitimate, independent of its content. In contrast, when the boundary object presents a socialized practice (vergesellschaftete Praxis), bringing up one's own perspective is only legitimate if it can fit the specific demands presented by this socialized practice. The empirical analysis suggests that the participation in the public user community mediated by the artifact present-at-hand is regulated by the rules of a socialized practice where the own perspective has to be legitimized with regard to the general interest (see Section 4.3). This is a relevant design issue for EUD research supporting the social dimension of appropriation work.

The second part of my thesis presented the constructional work which addresses the design challenge of using specific software features to support distributed evolution and incremental innovation development. In the constructional part, I demonstrated how the suggested model of boundary objects can be concretely interpreted in design terms. Using the artifact present-at-hand as centre of an in-situ design activity, I have developed a software-technical solution that enables the interweaving of a design context into the local use context. The design concept provides two major innovations with respect to existing solutions. Both innovations are closely related to the model of the situated evolutionary boundary object.

The first innovation was a result of taking the situated stance of CSCW seriously. The implicit assumption in current software design methodology is that the object of interests (OIs) can be tagged in the spatiotemporal design context, and that from a user perspective these objects will be identical to the tagged ones. Taking the results of CSCW research seriously,

this assumption becomes questionable because intention is a concept that can not be implemented into (intelligent) machines.

Following this line of thought, I went on to compare the objects tagged by users with the one tagged by the designer, and in doing so, I found proof that current software design methodology has only a heuristic value. Thus, I began to search for an alternative solution which was first implemented in CHiC (see Section 6.2). The innovative solution here was to increase the space of explicitly tagged OIs, making use of patterns in the construction of software artifacts (which are a result of historically shaped production practices). Such patterns can be used in a heuristic manner to algorithmically tag additional OIs in the use context.

The second innovation was to generalize the mediating role of software applications between designer and user as suggested by Mørch and Mehandjiev (2000). Taking up Marx's notion of products as mediators among a product community in combination with an understanding of artifacts present-at-hand as evolutionary entities provided the analytical foundation for exploring the concept of the "*Wiki inside"* design approach. The revisited architecture of Appropriation Infrastructures (see Section 5.4) takes further results on the different practices of appropriation work into account. Especially the suggested EUD room approach supports cooperative appropriation with a view to enhancing the specific evolution of a situated development trace. In addition, the first innovation Appropriation Infrastructure presents a sophisticated approach to interweaving a collaborative appropriation environment into the local use context, integrating the fragmented development traces in reaction to actual situations, thereby enabling integrative user experiences.

The design approach has been tried out in a case study, where several features of the Appropriation Infrastructure were integrated into a component-based groupware system called BSCWeasel. The appropriation of the Appropriation Infrastructure feature was observed from September 2005 to July 2007. However, some limitations of the case study should be mentioned with respect to commercial products. First, academic Action Research projects by habitus tend to have a pro-innovation bias. Second, BSCWeasel was Open Source, which did not follow the same rules as commercial software development. Last but not least, the number of users of the Appropriation Infrastructure was not very large, so that I could not present quantitative empirical results that are statistically significant in any way. However, my primary research interest was to inquiry into the underlying structure of situated development in distributed software evolution, and not to explicate a causal model where statistical significance makes sense. The observation process, and the additionally

conducted interviews and usability studies give a first impression of what it means to use an instance of an Appropriation Infrastructure in practice. For example, it became obvious that from the inner perspective on a wicked situation, the common design approach of separating help and feedback mechanisms into two isolated features is dysfunctional. Based on the aforementioned theoretical and practical insights into appropriation support, I have elaborated a modular architecture to implement Appropriation Infrastructure (see Section 5.4).

Having summarized key findings, I will conclude with some critical remarks, and based on this, develop an outlook for future work. My first remark refers to both the analytical and the constructive part of my thesis. The relationship between design practice, design theory, and design critique in general needs to be explored more in depth. When explicating my theoretical stance in the first part of the thesis, I wanted to motivate the constructive part of appropriation support from a conceptual foundation. However, the software-technical approach of Appropriation Infrastructures does neither present the only possible nor necessarily the optimal solution resulting from the theoretical conceptions. It may also be possible that another theoretical lens would lead to a similar design conception (e.g. Activity Theory, if it had integrated the appropriation concept systematically in its theoretical framework). Insofar, the relationship between the analytical and the constructive aspects of my work might be best characterized as an elective affinity, and maybe this is more generally spoken an appropriate understanding.

Rittel and Weber have shown that in the case of wicked problems, theories cannot provide direct answers to design problems. If the theoretical model of evolutionary anthropology is true, developing innovative products is inherently a wicked problem. Therefore, a design concept like the Appropriation Infrastructure's focus on innovation development in distributed settings may have to live with not being deducible from a theoretical model, as design theory cannot replace design practice in the case of wicked problems. Instead, design theory might be content with the role to sensitize, inspire, or criticize practice.

The second remark is related to the first one, and addresses the practical benefits of Appropriation Infrastructures. In particular, the experience of using the first version of an Appropriation Infrastructure has demonstrated that the concept is 'no silver bullet' (Brooks, 1987) for the economically risky endeavor of developing innovative products as described in Chapter 1. Still, the evaluation in practice showed that product development can benefit from mediated user feedback in different ways. Since software development is typically based on anticipated needs, Appropriation Infrastructures help to ground the development

in actual needs detected in the user's local context and therefore reduces the risk in product development.

Moreover, Appropriation Infrastructures support the actual trend of incremental development as worked out in Chapter 1, since the system is not only used to express actual needs but also to render the artifacts' use more efficient in the local context. Nevertheless there is a myriad of future work to be done. The following list presents my personal agenda on mediating fragmented work among product communities:

- empirical studies on design reflections in personal communication or self-organized communities (like talking about artifacts with friends, sharing adaptations with colleagues, etc.),
- case studies on Blended Participatory Design where the Appropriation Infrastructure acts as a PD-tool in combination with other PD-tools such as future workshops,
- improving the prototypical implementation to attain a standardized, stable version of a revised version of an Appropriation Infrastructure. In particular, it is worth looking at self-organized configuration management as part of distributed appropriation work,
- conducting case studies in which an improved version of the Appropriation Infrastructure would be rolled out in a commercial setting with thousands of users.

In summary, the actual technical and cultural evolution which is captured by the "2.0"-label, leads to new design opportunities as well as to new research questions to organize coproduction. Regarding this trend, the understanding and designing of appropriate infrastructures become a highly relevant topic in the software industry. My thesis should provide a valuable contribution at this point on an analytical as well as on a constructional level.

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1 Appendix: Publications on Appropriation Infrastructure

This dissertation is based on previously published papers dealing with the practical experience of designing flexible software systems and supporting their appropriation. Initially, my research interest focused on strategies of designing appropriate de-compositions for component-based tailorable software systems. However, studying suitable de-compositions beforehand, I became interested in the question how design and use context can be mediated in a better way. Therefore, I began to elaborate on the concept of appropriation as worked out by Volkmar Pipek. In particular, I began to explore the implications of appropriation work with regard to design methodologies and software design. The concept of Appropriation Infrastructures presents the first major outcome of my research efforts. The following publications document the winding path that led to this concept.

Description of main publications

First publication:

G. Stevens und V. Wulf (2002). „New Dimension in Access Control: Studying Maintenance Engineering across Organizational Boundaries". In: *Proceedings of the 2002 ACM Conference on Computer Supported Cooperative Work* (New Orleans, Louisiana, USA, November 16 - 20, 2002). CSCW '02. ACM Press, New York, NY, S. 196-205.

In the CSCW literature on End User Development, several technical approaches like OVAL (Malone et al., 1994a), Prospero (Dourish, 1995) or FreEvolve (Stiemerling, 2000) have been suggested to increase the tailorability of groupware systems. The opportunity to change the material and symbolic construction in the context of use is a prerequisite for EUD. Therefore, the work mentioned above provides some of the enabling technologies. However, these technology-centric approaches often neglect to study what kind of tailorability is needed in practice.

My publication presents an attempt to bridge the gap between software-technical approaches and ethnographic work on tailorability. It presents an ethnographic study of existing access control practices in a cooperative setting linking a steel mill and its external contractors. Figuring out rationalities and contingencies in the existing practices, the ethnographic study does not only focus on what exists but also asks for possible development traces within existing control practices that could be supported by a flexible access control solution. In particular, I demonstrate how the approach of Component-based Tailorability

(Stiemerling, 2000, Wulf et al., 2008) can be applied to implement a flexible access control system that goes beyond already existing concepts. However, when translating the ethnographic study into component design and letting users explore the developed solution, it became obvious that an appropriate approach must not only provide *technological flexibility* (Stiemerling, 2000) but also *interpretative flexibility* (Orlikowski, 1992).
With regard to this requirement, the publication demonstrates how a domain-language oriented design-approach by Züllighoven (2004) can be applied to component-based tailorability. This approach enabled me to create an access control system that is based on a P.O.-box metaphor and combines technical and interpretative flexibility.

Second publication:

A. Mørch, G. Stevens, M. Won, M. Klann, Y. Dittrich und V. Wulf (2004). "Component-based technologies for end-user development". In: *Communication of the ACM* 47(9) (Sep. 2004), ACM Press, New York, NY, USA, p. 59-62.
Motivated by experiences of bringing Component-based Tailorability into practice (cf. Stevens and Wulf, 2002), this publication elaborates on the question of how to combine technical with interpretative flexibility of software artifacts.
Discussing component-based software development, it becomes obvious that a holistic approach must combine technological, organizational, and user-experience perspectives respectively in order to support end users to perform their daily tasks.
Referring to the role of components, this publication tries to connect McIlroy's (1968) vision of software-engineering and Kay's (1977) perspectives on user-orientation..
McIlroy suggested that software-engineering should adopt techniques developed in the manufacturing industry so that software could be constructed from off-the-shelf components in the future. Kay pioneered the ideas of domain-specific components (GUI objects) and end-user empowerment through computer applications. He drew an analogy with a painters' palette and canvas and suggested application developers should provide end users with domain- specific design environments that would empower them to create a wide range of products within selected domains.
Linking Mørch's concept of Application Units and my concern with regard to domain-specificity, this publication presents an important step towards shifting a technology-centric view on tailorability towards a practice-centric perspective that addresses EUD from a qualitative, evolutionary concept of design.

In particular, this publication highlights the concept of "gentle slope" which allows users to modify a computer application through the user interface. This concept led to the idea of Appropriation Infrastructure as a means to interweave design issues into the use context. The concept of “gentle slope” has been generalized in my later work where I argue that ‘gentle slope’-implementations should take design discourses into account.

Third publication:

G. Stevens, V. Wulf and V. Pipek (2009). „Supporting the structuration of technology in use: Outline of an Appropriation Infrastructure”. submitted to *Journal of the Association for Information Systems*.

The third publication presents important parts of the theoretical framework of my thesis in developing the concept of appropriation which was introduced into IS research by Poole and De Sanctis (1989), and made prominent in CSCW-community by Pipek (2005a). Although in both cases there is a link to the Marxian origin of the concept, in my thesis the theoretical role of appropriation is different from the one in Poole and De Sanctis’s work as well as in the thesis of Pipek. We start from Pipek’s interpretation by understanding the appropriation of software as an inherently social process in which users engage in a number of learning, meaning creating, and configuration activities. Taking up the dialectic moment of the concept of appropriation, we develop a practice-oriented perspective on the problem of mediation and evolution of agency (as the competency of action) and structure (as the outcome and prerequisite of action).

Influenced by a CSCW-stance that is interested in supporting agency, the concept of Appropriation Infrastructure is promoted as a means for mediating the distributed and fragmented evolution of software artifacts and their usage.

We argue that software artifacts should integrate mediation features to foster such distributed processes. In particular, software artifacts should provide communication channels integrated into the user interface of computer applications. In this first version of a software technical realization of the concept, we decompose the architecture of Appropriation Infrastructures along the lines of user-designer communication and user-user cooperation. Interpreting the fragmentation problem from this perspective, the suggested software-technical concepts argue for two communication channels. A first type of communication channel supports the community of users in sharing knowledge with regard to an application’s usage. A second type of channel supports the communication between users and developers. This paper also documents experiences with the use of an instance of an Ap-

propriation Infrastructure. In order to describe and classify the different phenomena, a first version of an extended understanding of the concept of boundary objects was introduced.
The introduction to the papers presents a development of the concept of Appropriation Infrastructures at two points. Firstly, the publication presents the implemented system in a similar way as it is done in Chapter 6. Based on the analysis of the observed phenomena, Chapter 5 presents a general architecture that takes the learned lesson into account. Secondly, the publication argues for an extended understanding of the concept of boundary object. Elaborating on this finding from an analytical perspective, Chapter 4 presents a refinement of the initial conception that (against the intention of the author) becomes unfortunately more abstract, but nevertheless also more precise in characterizing the different roles of boundary object can play in mediating appropriation.

Fourth paper:

F. F. Mueller, G. Stevens, A. Thorogood, S. O Brien und V. Wulf (2007). “Sports over a Distance“ In: Personal and Ubiquitous Computing 11(8), Springer-Verlag, London, UK, S. 633 - 645.

The fourth publication explores the topic of experience-based design in the field of ubiquitous computing. This work on new design methodologies was influenced by the dialectic understanding of appropriation of and realization in nature. Instead of separating appropriation (as something done by users) from realization (as something done by designers) this publication is influenced by an understanding of appropriation and realization as constitutive elements of both use and design, and the role of practical experience and collaborative reflection in design.
From this perspective, the publication presents a revised model of the Wizard of Oz conception. This revised model was used to reflect on embodied experience using and designing a prototypical implementation of a computer-mechanical flight simulator, called FlyGuy. In contrast to ordinary desktop applications, the FlyGuy presents an exertion interface, where the embodied experience plays a critical role.
Traditionally, in a Wizard of Oz evaluation, a human actor, a hidden wizard, simulates the system’s behavior by interpreting the user’s input and creating a suitable output behavior (Preece et al., 1994). The original intent of the approach was to create a situation that allows users to appropriate the future development of the system in an early phase, so as to evaluate whether the design idea will meet its needs. So, the primary goal was to support

user appropriation and reflection on the experiences gained in order to anticipate emerging needs in a faster and a more accurate way.

However, taking into account that realization is not separated from appropriation, the revision of the Wizard of Oz method introduces the concept of a systematic discursive reflection on embodied experiences. Apart from the extension of the conceptual level, we also enhanced the method on a technical level by introducing two additional wizards to meet the specific physical requirements of forced feedback.

The simulation of a future application can be interpreted as a special form of in-situ design, where the action of the Wizard of Oz is a simulation of an appropriation and realization process, because the Wizard of Oz is confronted with immediate constraints (e.g. physical constraints of the steering control) or anticipated constraints (e.g. that her situated actions will be replaced in a next step by an algorithm). However, not all of these constraints are explicit and known in advance, still they must be appropriated. Moreover, from the manifold of simulating future applications, the Wizard of Oz is forced to make an in-situ design decision. By simulating the application, the Wizard of Oz has to appropriate the potentiality for design, not just for the users but also for the designers reducing the symmetry of ignorance.

Description of supplementary publications

Fifth publication:

G. Stevens und T. Wiedenhöfer (2006). „CHIC - a pluggable solution for community help in context". In: *Proceedings of the 4th Nordic Conference on Human-Computer interaction: Changing Roles* (Oslo, Norway, October 14 - 18, 2006). A. Mørch, K. Morgan, T. Bratteteig, G. Ghosh, and D. Svanaes, Eds. NordiCHI '06, vol. 189. ACM, New York, NY, 212-221. p. 212 – 221.

One of the goals of the Appropriation Infrastructure concepts was to bridge the fragmentation of distributed experience by stimulating knowledge-sharing among users. To support collaborative reflection among users, we enhanced traditional help approaches with new concepts which we called Community Help in Context (CHiC). The publication presents design concepts for integrating Wikis into application interfaces, so that there is a more seamless transition between the use context and the Wiki understood as a Help System. The publication also describes a prototypical implementation of CHiC based on Eclipse.

Sixth publication:

G. Stevens and T. Draxler (2006). „ Partizipation im Nutzungskontext (Partizipation in use context)". In: *Proceedings of the* Mensch & Computer 2006. A.M. Heinecke and H. Paul, H. Eds. Oldenbourg Verlag, München. p. 83 – 92.

Another goal of the Appropriation Infrastructure concept is to support the cooperation between designer and users. Traditionally Participatory Design (PD) mainly focuses on methods that support the participation in early stages of the software development process. However, the continuous development of software artifacts enables new forms of participation, in particular, distributed participatory design in post-deployment phases (Nichols et al., 2003). Picking up on this trend, the publication presents an approach to integrate PD-features into applications to enable a more seamless transition between use context and a public design discourse. The publication also describes a prototypical implementation of this approach which is based on Eclipse.

Seventh publication: G. Stevens, S. Draxler and I. Wienke (2008). „Zum Handeln in Krisensituationen: Ein Beitrag zur Strukturationsdebatte". In: *Multikonferenz Wirtschaftsinformatik MKWI'08*, München, GITO-Verlag, Berlin (CD Supplement).

The seventh publication uses the concept of appropriation as an analytical lens to study human-computer interaction. Following the heuristic that contradictions are forces of development, we focus in the publication on breakdown situations in the use of software artifacts. The theoretical part - the discourse on appropriation in IS research- is related to the related work on breakdown situations in HCI and CSCW research. The empirical part presents a sequence-analysis of a breakdown situation, demonstrating the conceptual proximity with Dewey's (1938) pattern of inquiry.

The analysis of the empirical case investigate the conceptual connection between the dialectical school of thought in the tradition of Marx and Hegel and the Pragmatist school of thought in the tradition of Peirce, Dewey and Mead. Moreover, it becomes obvious why both schools of thought are interesting for elaborating on a non-positivistic theory in Design Science. In my thesis, I draw on both of these schools of thinking because they argue from an evolutionary stance and rely on a concept of practice that is given by a contradictory unity of action and reflection.