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**Volkmar Pipek**  
*Negotiating  
Infrastructure:  
Supporting the  
Appropriation of  
Collaborative Software*

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# Table of contents

<b>Table of contents</b> .....	<b>2</b>
<b>Impressum</b> .....	<b>2</b>
<i>Negotiating Infrastructure: Supporting the Appropriation of Collaborative Software</i> .....	3
Volkmar Pipek .....	
<b>Biographies</b> .....	<b>46</b>

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## Impressum

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# Negotiating Infrastructure: Supporting the Appropriation of Collaborative Software

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<b>1</b>	<b>Introduction</b>	<b>5</b>
<b>2</b>	<b>Collaborative Tailoring and Appropriation Support</b>	<b>7</b>
2.1	<i>Continuing Design in Use</i>	7
2.2	<i>Supporting Collaborative Tailoring</i>	8
2.3	<i>Collaborative Tailoring of and in Heterogeneous Infrastructures</i>	10
2.4	<i>Appropriation activities beyond collaborative tailoring</i>	10
2.5	<i>Towards Appropriation Support: Two studies</i>	11
2.5.1	Negotiating Technology: Use Discourses	12
<b>3</b>	<b>Designing Appropriation Support for an Inter-Organisational Technological Infrastructure</b>	<b>14</b>
3.1	<i>Workshop Setting and Goal</i>	14
3.2	<i>The Support Concept</i>	16
3.2.1	Providing a Communication Platform	17
3.2.2	Providing Process Guidance and Facilitation	18
3.2.3	Supporting technology-related articulations	20
<b>4</b>	<b>Trial and Evaluation</b>	<b>21</b>
4.1	<i>Evaluation Methodology</i>	21
4.2	<i>The Course of the Online Workshop</i>	22
4.2.1	Start and Critique Phase	22
4.2.2	Idea Creation Phase	23
4.2.3	Realisation Phase	24
4.3	<i>Workshop Evaluation: General Aspects</i>	24
4.3.1	Background of the interviewees	24
4.3.2	Evaluation: Results vs. Effects	25
4.4	<i>Trial Analysis: Online Discourses about software artefacts</i>	26
4.5	<i>Trial Analysis: The Future Workshop Concept</i>	27
4.6	<i>Trial Analysis: Productive vs. Infrastructural Work</i>	28
4.6.1	Inter-organisational Issues	29
4.7	<i>Evaluation Summary</i>	30
<b>5</b>	<b>Discussion</b>	<b>31</b>
5.1	<i>Technological Support for Appropriation</i>	31
5.1.1	Support for Demonstration and Negotiation	31
5.2	<i>Organisational aspects</i>	35
5.2.1	Opportunities for reflection	35
5.2.2	Future Workshops in Appropriation Processes	36
5.2.3	Framing conditions of Appropriation Support	36
<b>6</b>	<b>Future Directions of Research</b>	<b>37</b>
6.1	<i>Reconsidering 'Infrastructure'</i>	38
<b>7</b>	<b>Conclusion</b>	<b>39</b>
<b>8</b>	<b>Acknowledgements</b>	<b>41</b>
<b>9</b>	<b>References</b>	<b>41</b>

**Abstract.** A growing body of research work tries to go beyond the classical dichotomy of ‘design’ and ‘use’ in order to better understand the accountabilities of technology production and use. Our research focuses on the creative activities at the ‘user’ end of the production line of organisational software. Support for these activities is traditionally discussed in the context of ‘Tailoring’ applications for specific organisational contexts. In earlier studies we were able to identify ‘appropriation activities’ beyond tailoring, like technology-related communication and technology demonstration, which ‘users’ perform in order to make sense of technologies for their practical needs. In this study we report our experiences with developing and conducting means for ‘appropriation support’ to actively facilitate these activities. We developed and implemented a ‘use discourse environment’ following the idea of an ‘Online Future Workshop’ to facilitate the discussions around the establishment of a shared software development infrastructure of four cooperating research organisations. We provided a highly accessible platform (a web-based discussion forum), a goal-oriented discourse and facilitation concept (inspired by the idea of a Future Workshop), and additional articulation support (easier quoting of software artefacts).

Our results indicate the usefulness of easy reference to and illustrations of the technology in discussion, the need for process guidance, the need for a stronger integration of work context and appropriation support means, and the increased difficulties through multi-faceted organizational and individual interests that occur in an inter-organisational, distributed environment. The subordinated nature of ‘infrastructural work’ (versus ‘productive work’) could be identified as the main problem for appropriation support concepts. However, our study encourages research beyond an analytical perspective on appropriation phenomena. On the one hand, the support of these activities can become an important aspect of designing the technologies themselves, on the other hand support approaches like the one described here help render visible the ‘invisible work’ appropriation activities constitute, making this type of work also more accessible for an analysis of the dynamics at work.

## 1 Introduction

Integrating new and innovative artefacts of Information Technology, software or hardware, for a specific field of application is inherently difficult. A description of a typical design situation in the field of Information Technology involves “users” (people with knowledge of the application field and the tasks which have to be done there) and “designers” (people with knowledge of the technology and its possible uses) as main actors, and an IT artefact and its potential usages as the focal point of interest and activity. There is a design process that may or may not involve direct interaction between the actors, but that has an artefact as an outcome that is considered helpful for users in an application field or in an imagined use scenario. The defining success measure of that process is whether or not the intended usage turns into real usage, whether or not the artefact is considered helpful by a large number of intended users.

Current approaches to software development for organisations respect that the “users”’ opinions and perspectives are highly valuable for a successful outcome of a design process, and offer different ways of integration (e.g. Unified Process/Use Cases, e.g. Scott 2002 or User-Centred Design, e.g. Vredenburg et al. 2001, Galer et al. 1992) or participation (Participatory Design, e.g. Mumfort 1981, Ehn and Sjørgen 1991, Schuler and Namioka 1993, Kensing and Blomberg 1998) of users in the design of software artefacts. But – historically understandable – these approaches still mainly address designers’ interests and perspectives, and designers have been the main audience of the methods developed. Our research interest picks up the other end of the ‘production line’ of organisational software: How do users contribute to the accommodation of groupware technologies in a concrete application field and concrete use situations? Or put differently: What kind of “design” is there in “use”, and performed by “users”? The goal of our research is to develop means to support these user activities in this process of practical sensemaking of technologies. We will refer to these means as “appropriation support”.

The research is in line with recent efforts to establish a more accurate picture of technology production and use. Suchman (2002, and earlier in 1994) pointed out that “change ... is no longer the prerogative of professional design, but an aspect of everyday practice” (Suchman 2002, p. 99). She coined the term “Artful Integration” to illustrate a holistic perspective on systems development as a “cultural production of new forms of material practice” far beyond current techno-centric notions of design processes, in which “located accountabilities” beyond “the user” and “the designer” reflect the diversity of roles and contributions involved. A growing body of studies of the evolution of usages of organisational software illustrate her point (Orlikowski 1992, Robertson 1998, Karsten and Jones 1998, Pipek and Wulf 1999, Dittrich et al. 2002, Hansson et al. 2003, Törpel et al. 2003, Karasti and Syrjänen 2004). In these studies it became very visible that during “use” there is “user”-initiated creativity beyond design processes (and methodologies) and beyond “designer” participation, which aims to alter tool configurations, combinations and usages.

In our effort to find and support “user” activities that frame the evolution of usages we took “Tailoring” as an important starting point (Henderson and Kyng 1991, Trigg et al 1987). Henderson and Kyngs (1991) discussion on “continuing Design in Use” lead tool designers to provide the flexibility to “tailor” software to make it fit different, unanticipated or changing organisational contexts and use scenarios. Tailoring became the best-supported practical sensemaking activity of users, but we were able to show that there are more activities of user-user communication and demonstration that shape an appropriation process, and that should be supported with adequate tools. On the other hand we can show that the tailoring discussion has a ‘blind spot’ since concepts and solutions have always be concerned with one tool only, which does not reflect today’s organisational

practice of orchestrating a rich diversity of tools and technologies to maintain a work infrastructure.

We studied ‘appropriation activities’ of users as a collaborative effort to make sense of technologies for their work (Pipek and Wulf 1999, Törpel et al. 2003). The application field we encountered in the case presented here posed specific requirements for offering appropriation support: In an inter-organisational setting a shared development infrastructure for a strategic research and development project had to be discussed, decided and configured to fit the shared as well as the local development technologies and traditions. A diversity of existing tools had to be appropriated for a shared development effort. We developed the “Online Future Workshop” as a practical example for ‘appropriation support’ in this kind of work infrastructures. Our results deepen the understanding of appropriation activities and processes, and of the framing conditions that support concepts have to cope with.

We develop our argument as follows: First we summarise previous work on support for collaborative tailoring, and develop our notion of appropriation support in infrastructures. In the middle part of this paper we describe the setting and approach of the Online Future Workshop, its course and its evaluation. In the final discussion we point out what opportunities and obstacles should be considered when developing appropriation support concepts. We point out future directions of research before we close with a summary.

## 2 Collaborative Tailoring and Appropriation Support

Our focus is on the activities that users perform to appropriate a collaborative technology or infrastructure. It is obvious, that the configuration of a groupware is an important activity in the process of fitting it into a work setting (an ‘appropriation activity’). This activity of “tailoring” a groupware has already received some attention from researchers, but we can also describe shortcomings of the existing approaches, from which two are especially relevant in the context of this contribution: the missing support for further appropriation activities (communication, demonstration), and the failure to address issues ‘beyond one tool’ (tailoring in tool infrastructures).

### 2.1 Continuing Design in Use

To fit the changing needs of group work in organizations, the technological infrastructure (i.e. the software tools) has to be flexible, and the flexibility has to be manageable for the users. The core question in the tailoring discussion is what can be done to adapt tools and related work practice in a use context to each other

in order to support cooperative work appropriately (Henderson and Kyng 1991, Trigg et al. 1987). It has also been discussed how these aspects change the basic design of the software artefacts which are to be tailored.

The “architectural” perspective explored tailorability to develop concepts and examples for very flexible software systems, which could be adapted to their use scenarios (Maclean et al. 1990, Malone et al. 1992, Morch 1997, Stiemerling and Cremers 2000). Object-Orientation (Morch 1997) and Component-Based Systems (Stiemerling and Cremers 2000) have been explored to increase the flexibility of software artefacts designed to support group work, other approaches addressed issues of analyzing, separating and composing tailoring entities along the typical functionality of CSCW systems (Malone et al. 1992, Teege 2000).

The “user-interface” perspective explored how tailorable software should present itself to the tailors. Henderson and Kyng (Henderson and Kyng 1991) distinguished three levels of tailoring (choosing between predefined alternatives, constructing new artefacts from existing pieces, and reprogramming the artefact) that require different levels of expertise regarding the supporting technology. Obviously, ordinary groupware users cannot be expected to acquire programming skills to be able to tailor an artefact accordingly. Several approaches, some inspired by Nardi’s (1993) work on end-user programming, aim at developing tailoring environments that provide simple concepts and interfaces for end-users (MacLean et al. 1990, Malone et al. 1992, Stiemerling et al. 1997, Teege 2000). Wulf and Golombek (2001) aimed at qualifying end-users for tailoring by providing a sandbox environment for the exploration of tailoring effects.

## 2.2 Supporting Collaborative Tailoring

The role collaboration takes in tailoring activities can be distinguished according to the technical and organizational ties that bind users together and motivate this collaboration. We distinguish four scenarios (in more detail described in Pipek and Kahler 2005):

- “Shared Use” scenario: Collaboration for tailoring a tool that every user uses independently and individually.
- “Shared Context” scenario: Collaboration for tailoring a tool that every user within a shared context (organization, virtual team) uses individually.
- “Shared Tool” scenario: Collaboration for tailoring a tool that several users use simultaneously.
- “Shared Infrastructure” scenario: Collaboration for tailoring a set of tools, devices and technologies used by users in a (at least partially) shared context.

Focusing on technical support for particularly collaborative tailoring we will concentrate on the second and third scenario described here. We deal with the fourth scenario further below.

A first prerequisite of collaboration in tailoring was the “objectification” of changes done to the artifact to tailor (including the option to name a tailoring object accordingly). This requirement has already been addressed already in early research initiatives (MacLean et al. 1990, Mackay 1990), and is still under exploration regarding potential benefits in its relation with classical “Object Orientation” in Software Engineering (Morch 1997, Kleinen 2003).

For “Shared Context” scenarios, several concepts have been developed and evaluated. MacLean et al. (1990) allowed sending tailoring objects via email to other users in an organization. Wasserschaff and Bentley (1997) extended the Shared Workspace system BSCW by configurable and exchangeable views on the data stored (Tviews). Kahler (2001a, 2001b) developed and evaluated a prototype for the exchange of tailoring objects for a well-known text processor. He developed a repository and browser to store and retrieve tailoring objects like button bars, macros or menu structures on a central server of an organization. In most of these approaches, the object creator could describe meaning and use of tailoring objects with annotations.

The new quality of “Shared Tool” scenarios is that users inherently have to agree on a certain configuration of a tool. Nardi and Miller (1991) described a scenario of the collaborative tailoring of spreadsheets, where users had to agree on the “right” way of computing the necessary results.

Wang and Haake (2000) presented CHIPS, a hypermedia-based CSCW toolkit with elaborated abstraction concepts (role models, process models, cooperation modes, etc.) in a three-level modeling scheme (meta-model, model and instance) that allows users to describe and tailor their cooperation scenarios. Generally based on an open hyperlink structure the system is extendable on any modeling level and thus should be able to support every cooperation scenario that may occur. In this respect it is similar to CSCW toolkits earlier proposed by Dourish (1996) or Malone et al. (1992). Wang and Haake focus on the notion of tailoring as a collaborative activity. The main example they use to present the toolkit is the collaborative development of a work environment for a newly formed team. Their toolkit provides access rights systems and discourse representation facilities were inspired by the method of issue-based information systems (IBIS, Rittel 1973, Conklin and Begemann 1988). The tailoring activity is incrementally described and performed within the hypermedia system as any other collaborative activity. In their example they use a weak process model with the steps idea creation, discussion of alternatives, decision making and implementation. The approach does not explicitly implement this process but the tools (especially the model and instance editors) are designed to facilitate that process. The major drawback is that the cognitive costs for end users to apply the approach are very high (it requires understanding the modeling layers, the abstraction concepts and the tools). This might be acceptable in complex or model-oriented work environments (e.g. software engineering), but even then depending on the

granularity of the modeled descriptions the work costs of keeping the models up to date might well outweigh the perceived benefits.

### 2.3 Collaborative Tailoring of and in Heterogeneous Infrastructures

The fourth scenario we like to address gained importance over the last years. Current computer workplaces usually consist of a multitude of tools, technologies and devices on different technological levels. These infrastructures (Dourish 1999, Hanseth and Lundberg 2001) have not been addressed by the discussion on collaborative tailoring; the considerations usually circulated only around one tool or technology. However, aside from obvious dependencies (e.g. between a Shared Calendar Tool and an LDAP-Server that serves as the underlying database system), the use of several tools in a work activity creates hidden dependencies between these tools that lead to a mutual dependency of tailoring activities among users. This scenario carries aspects of the “Shared Context” scenario (mutual dependency of work activities) as well as “Shared Tool” scenario (enforced agreement regarding tool configurations and use). The application field we encountered here represents such a “Shared Infrastructure” scenario. A major obvious challenge for such a prototype is the potential technological heterogeneity the prototype has to fit in to be operable by all users involved.

### 2.4 Appropriation activities beyond collaborative tailoring

With “tailoring”, the configuration of software artefacts has been addressed as an important activity in the process of putting a technology into use. But the practical studies done in the context of tailoring revealed additional appropriation activities users perform around the task on configuration.

Mackay (1990) showed that the “sharing” of tailoring concepts not only involves the transfer of a technical entity (e.g. a ‘tailoring object’), but also surrounding activities of asking, suggesting improvements, explaining, understanding or communicating new ideas (p. 213). She also described the users needs for evaluating and recommending tailoring alternatives. Trigg and Bødker (1994) describe “learning” as an important activity in the context of tailoring activities, and they point out, that this does not necessarily involve the technology experts (designers, tailors, ...) but often just the physically nearest co-workers (p. 51). They refer to learning as an opportunistic (driven by the worker’s own needs and those of co-workers) and collaborative process. All these activities have only found very limited support in the technological support concepts (e.g. by providing support for annotation) for tailoring. MacLean et al. (1990) use a communication tool (E-Mail) for the distribution of the available tailoring activities, but they do not describe whether the activities mentioned above have been reflected in the related email conversations.

The ultimate reason for “continuing design in use” is to achieve a congruency of work tasks and tool support again and again in changing work contexts. Tailoring support delivers an important contribution, but the studies and evaluations show that to successfully develop usages, activities beyond reconfiguring the tools are necessary. The “additional activities” users engage in (as described above) still refer to technological changes and help (re-)establishing that congruency by changing or inventing usages. But it is not necessarily a change in a configuration that reflects a change in the use of a tool. Mark (1997) reported on the role of use conventions for groupware usage. Though Prinz et al. (1998, p. 379) describe tailoring activities as implementations of conventions; the conventions may change usage without any technological change. Orlikowski (1996) described the evolving use of a helpline support software. Far-reaching usage changes were initiated and implemented by users without actually changing the software. The software offered a text field for documenting the incident history of a call. Evolving conventions helped users in improving the descriptions to be better understandable as well as better retrievable by text search. Text quality soon became a matter of self-representation and expertise demonstration, and the search heuristics of the helpline staff reflected that issue. But users also developed “mis-usages”, e.g. the text field was also used for communication between managers and the helpline staff regarding the helpline incidents.

These examples illustrate that for the goal of establishing a congruency of tasks and tools, providing “tailorability” is useful, but maybe more can be done to support these processes.

## 2.5 Towards Appropriation Support: Two studies

In two long-term studies (Pipek and Wulf 1999, Törpel et al. 2003) we followed the emergence of groupware usages in two organisations. In very different settings, a German authority that introduced a groupware system and a network organization of freelancers that tried to develop and introduce a standardised groupware solution for the whole network, we observed the appropriation of different technological options that had been offered to individuals and the organizations as a whole. In several examples we illustrated, how usages have been invented or transferred. We identified *manipulating* technologies (we refer to that as “tailoring to a specific use”), *demonstrating/observing* technology usages or *communicating* (often more concrete, negotiating) about conventions, technological options and work artefacts as important activities users perform to appropriate a collaborative technology. It also became clear that appropriation activities are often considered secondary tasks that do not directly contribute to work goals, and that have to stand a tough cost-benefit-evaluation before users engage into them.

For the development of our prototypes, the following aspects, derived from the long-term studies as well as the experiences with tailoring environments, had to be considered:

- Integration: Similar to Trigg and Bødker's (1994) requirement for tailoring environments that are integrated in the tools to configure, technological means to support appropriation should also be integrated in the artefact that is being discussed or tailored.
- Simplicity: As the articulation of usages is particularly valuable for less experienced users, the perceived complexity of use has to be lower (and sometimes significantly lower) than the complexity of using the technology that is being discussed.
- Prepared for Ad-Hoc Use: As technology appropriation will always remain a secondary aspect of work, any support concept or tool should allow quick and easy use of it.

Learning from these experiences, in this contribution we aim at supporting appropriation by offering means for a technology-centred discourse ("*Use Discourses*") for a "Shared Infrastructure" scenario.

### 2.5.1 Negotiating Technology: Use Discourses

The basic idea of our approach is to extend artefacts and infrastructures with "Use Discourse Environments" (technological means for particularly user-user-communication and –demonstration regarding the usage of the tools and artefacts). For an informed realisation of this basic idea, it is helpful to draw on experiences made regarding issue-centred online communication.

There are already a number of approaches that address the issue of a design-oriented communication. Though focusing on the documentation of design decisions ("design rationales", Moran and Carroll 1996) and their dependencies, the design rationale concept inherently applied a dialogical structure and used arguments to document the different alternatives and the decisions made. Beyond only documenting the process, some of the argumentation-based approaches also aimed at supporting the designer-designer interaction during a design process (Fischer et al. 1996, Reeves and Shipman 1992)

Some of these approaches relate to the idea of Issue-Based Information Systems (IBIS) proposed by Rittel (1972). In this concept to support the solution of complex ("wicked") problems he proposed the use of persistent structured conversations using the speech acts "issue", "position" (opinion on an issue) and "argument" (for or against a position), which have defined relations. This concept has been implemented and improved (Conklin and Begeman 1988, Gordon and Karacapilidis 1997), but it has also been criticized for still being too formal to be attractive for all problems and all user groups (Isenmann and Reuter 1995, Shipman and Marshall 1999). Similarly, Whittaker (1996) reported that guidance

and facilitation also run into the danger of inhibiting instead of facilitating discourse even for weaker structured approaches.

Some weaker-structured approaches do not support an explicit design process, but offer support for conversations related to an artefact or its representation with the goal of changing or commenting it. In the D3E-Environment of Sumner and Shum (1998), discussion of a document is supported in a way that comments and commented parts of the document always are visualized together, and the “Sticky Chat” concept Churchill et al. (2000) developed for a widely-used text processor supports persistent chats related to paragraphs of the text. Reeves and Shipman (1992) supported artefact-centred communication for computer network design. All these approaches focus on the integration of discourse and issue representation, and informed our approach in this respect.

Taking a step back, Churchill and Erickson (2003) aimed at developing a deeper understanding of artefact-centred mediated conversation. Some considerations are highly relevant for our idea. First, the notion that artefact-centred mediated conversation is often not a conversation about things but representation of things is important, because it reminds us that though we discuss tool configurations and tool usage, we can address the *collaborative work* that actually is the true focus only by means of representations of some of its aspects. Second, the embedding of reflections that constitute a “mediated conversation” into a perspective of supporting “articulation work” (Star and Strauss 1999) and the challenge to reduce it by developing appropriate technological support (Schmidt and Simone 1996) ties the discussion to the research on cooperative work settings.

Duchenaud and Bellotti (2003) addressed in their analysis of email conversation in an organization the issue of understanding references (textual, by attachment, by URL, etc.) to artefacts. They found out that the establishment of a meaning for these references is less dependent on the form of the reference and more dependent on the shared understanding that emerges from longer conversation practice. Email seemed to be appropriate especially when referring to things that already were in a “digital” form. Martin and Rouncefiled (2003) pointed out that there also can be “wrong” references interrupting the natural flow of conversation. Especially is there no point in providing as many representations and references as possible; the important issue is to provide the right reference at the right time (maybe achieved by a joint management of currently visible references). Zuiderent et al. (2003) stressed that the current communication technologies themselves offer only very limited context for conversations. To establish a context, additional work has to be done by a message sender in a conversation, which requires additional media-related skills. They pointed out that the organisational issue of who is responsible for doing that additional work is a critical factor for successful mediated conversation. Whittaker (2003) focuses on visual information about things that are in discussion, and comments that it is

not always necessary to use visual information to illustrate arguments. But if considered valuable, it has to be carefully judged *what* information is shown *how* and *in what thematic context*.

What does this mean for the design of ‘Use discourse environments’? With the experiences regarding the combination of information/ representation spaces and argumentation/articulation spaces we find the aspect of integrating the tailoring environments and the use discourse we associate with a tailoring activity into the collaborative software confirmed. Vice versa, the value of quoting (representations of) the issue of a discourse is also a critical aspect. Regarding our requirement for simple, ad-hoc usable concepts for appropriation support the issue of structuring discussions in a formal way or enforcing the categorisation of contribution has to be treated cautiously. On the other hand, it is valuable to represent appropriation activities also as converging processes (i.e. with a negotiable but defined organisational and temporal scope) in order to keep up the notion of a use negotiation (especially in “Shared Tool” scenarios). Concepts for supporting a use discourse should be aware of the additional services that persistent solutions (with the appropriate browsing and retrieval facilities) may provide.

### 3 Designing Appropriation Support for an Inter-Organisational Technological Infrastructure

Above, we described our basic idea to extend existing support for tailoring with “Use Discourses” to support users in further appropriation activities. The idea of “Use Discourse Environments” that support these appropriation activities is quite general and has to be specialised for every application field. Here, we develop an online workshop concept that specialises our idea for “Shared Infrastructure” scenarios. In this section we describe the details of the application field and the support concept we developed.

#### 3.1 Workshop Setting and Goal

The “appropriation problem” we encountered in this case was the appropriation of several tools and technologies to form a shared work infrastructure between research groups in four academic departments in Germany we call Alpha, Beta, Gamma, and Delta here.

Alpha is a research group in the computer science department of a university in western Germany. The group focuses on research on Human-Computer Interaction (HCI) and Computer-Supported Cooperative Work (CSCW) and had about 15 full-time or part-time members. Beta is a research group on Geographic Information Systems (GIS) of the Geosciences department at the same university,

and had about 6 members. Gamma is a research group on group-oriented HCI issues at a state-funded federal research institute in a smaller city about 15 kilometers away from Alpha. It had about 40 members, but only 3 were engaged in cooperation relevant in this context. Delta is a research group on media systems at another university in a town about 80 kilometers away from Alpha, with 4 members.

Between most of the participating research groups there were close personal as well as organisational relations, there were ongoing research activities between Alpha and Beta, Alpha and Delta, and Gamma and Delta. Alpha had produced an innovative framework for component-based software development (based on the Java programming language), and mediated through other research activities, the other organizations got interested in extending it and/or using it in the development of their own prototypes. Beta planned to use the framework in a project they conducted in cooperation with Alpha, Gamma planned to extend and use it in one of their research projects, and Delta had (together with Alpha) applied for national research funding regarding the further development of the framework.

The groups took a strategic decision to cooperate regarding the further development of that framework in the autumn of 2002. Each of the participating organisations had its own tool infrastructure for software development with different but similar tools for collaboration (Programming Tools like IDEs, Code bases, Versioning Systems, Documentation tools).

The existing tool infrastructures within the groups were not very elaborated. They stored the code bases of their project as well as the documentation in file systems, and only Gamma had established a versioning system (CVS<sup>1</sup>). At the time the workshop started, the group members were using NetBeans<sup>2</sup> as well as Eclipse<sup>3</sup> as IDEs, but there were also people developing with programmer-friendly editors and command-line compilers. These tools were supplemented by standard email tools for communication, standard calendar tools for project planning and standard office tools for documentation and presentation. Group members were working with personal code bases, and code exchange usually happened via email. The group infrastructures based on the Windows 2000<sup>4</sup> operating system.

The members from the research groups formed a rather homogeneous set of potential workshop participants. All of them studied or had studied computer science at least as a minor subject; most of them had a master's degree. All of

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<sup>1</sup> <https://www.cvshome.org/>

<sup>2</sup> <http://www.netbeans.org/>

<sup>3</sup> <http://www.eclipse.org/>

<sup>4</sup> <http://www.microsoft.com/windows2000/>

them were using the Internet also for private purposes and had at least 8 years of experience.

The goal of the workshop was to establish a shared infrastructure for the further development of the framework. The local infrastructures provided a choice of available technologies for the shared infrastructure that formed the technological basis from which tools had to be appropriated. To generate the shared infrastructure necessary for the joint development effort, these tools had to be replaced or tailored and potentially supplemented by additional tools e.g. for versioning. So, the “infrastructure tailoring” would potentially not only involve existing, known tools, but also new tools or even new kinds of tools with a stronger focus on managing collaboration. The discussions were expected to focus on the choice and configuration of development and collaboration tools, but to cover more general questions regarding cooperation during the joined framework development as well.

The notion of “infrastructure” within the research groups before the workshop was a rather technical one, but in the workshop announcement also the necessity for organizational conventions (regarding information flow, documentation, etc.) was explicitly mentioned.

The workshop goal was shaped in negotiations (via telephone/email) between the “elder” group members. In these discussions it also became apparent that the problem remained in a grey zone of “secondary” tasks. It was considered not important enough to schedule a Face-to-Face workshop to discuss the issues, but important enough to somehow take care of it. According to our experiences described in Pipek and Wulf (1999) and Törpel et al. (2003) we consider this a typical situation in the context of appropriation processes.

### 3.2 The Support Concept

The “appropriation problem” that was shaped by the strategic cooperation initiative of the four organisations and the negotiations about establishing a shared infrastructure goes far beyond the typical setting of fitting one new (collaborative) tool into an existing infrastructure. The following consideration guided the design of our support concept.

For an optimal outcome, it was necessary to allow the broadest user participation possible, requiring an easily accessible and easily integratable base technology and simple, transparent concepts. The inter-organisational setting called for the provision of means to socialise over organisational boundaries to allow the establishment of a necessary level of trust. The nature of appropriation activities as secondary tasks required basic facilitation (to maintain a certain level of awareness) and process guidance (to allow a transparent, convergent process). The expected discussion issues (tools, configurations, usages) called for easy opportunities to integrate references to external tool and usage descriptions into the articulations. We tried to amalgamate these requirements into a socio-

technical appropriation support framework that we now describe in more detail regarding the provided means for communication, the means for process facilitation and guidance, and the means for integrating references to representations of the issues under discussion.

Foren	Inhalt	letzter Beitrag	Moderatoren
<b>Foyer</b> Anmeldung, Informationen, Pausenräume			
<b>Testforum</b> Hier darf man wirklich alles machen ...	23 Themen 42 Beiträge	<b>Sperren? (Alpha-Alpha)</b> 24.06.2003, 20:07	
<b>Pausenraum</b> freie Diskussion für alle	4 Themen 13 Beiträge	<b>Wo bleiben die anderen? (Volkmar Pipek)</b> 27.06.2003, 13:12	nudersch, Volkmar Pipek
<b>Support</b> Hier sind alle Fragen zum Workshop, zu benutzen Tools usw. erwünscht.	12 Themen 35 Beiträge	<b>Weiterleitungen (Volkmar Pipek)</b> 21.06.2003, 22:08	nudersch, Volkmar Pipek
<b>Materialien</b>	3 Themen 7 Beiträge	<b>Einleitung zum Online-Workshop (nudersch)</b> 14.12.2002, 17:14	nudersch, Volkmar Pipek
<b>Foren Zukunftswerkstatt</b> "Infrastrukturen zur Weiterentwicklung von FreEvo"			
<b>Kritikphase</b> 13.12.2002 - 24.1.2003 Forum geschlossen, bitte nicht mehr diskutieren.	9 Themen 26 Beiträge	<b>Kritik zum Thema "FreEvo" (freddy)</b> 22.01.2003, 16:35	nudersch, Volkmar Pipek
<b>Utopiephase</b> 10.3.-6.4.2003	4 Themen 11 Beiträge	<b>Kommerzielle IDE? (Volkmar Pipek)</b> 05.06.2003, 09:46	nudersch, Volkmar Pipek
<b>Umsetzungsphase</b> 28.4. - 25.5.2003	12 Themen 13 Beiträge	<b>Einheitlicher Entwicklungsprozess (won)</b> 07.07.2003, 15:24	nudersch, Volkmar Pipek
<b>Werkstätten/Nebenforen</b>			
<b>Vorstellungsrunde</b> Kurzbeschreibungen der Beteiligten	9 Themen 9 Beiträge	<b>Vorstellung von Michael - Fr. (freddy)</b> 20.01.2003, 18:20	nudersch, Volkmar Pipek
<b>Forum aktuelle Probleme und Fragen</b> Software-Diskussionen zu FreEvo ausserhalb des Workshop-Themas	0 Themen 0 Beiträge		nudersch, Volkmar Pipek
<b>Sinn und Kritik</b> Fragen und Kommentare zum Konzept der "Online-Zukunftswerkstatt"	1 Themen 3 Beiträge	<b>Zeiteinteilung (Engelskirchen)</b> 17.01.2003, 13:08	nudersch, Volkmar Pipek

**Wer ist online?**  
Zur Zeit ist/sind 1 Mitglieder und 0 Gäste im Forum unterwegs. **Rekord:** 7 User am 17.12.2002, 12:03.

Volkmar Pipek

**Statistik** Legende

157 Beiträge in 77 Themen  
Registrierte Mitglieder: 28

neue Beiträge keine neuen Beiträge

Figure 1: Screenshot of the web-based discussion groups

### 3.2.1 Providing a Communication Platform

From the experiences described in earlier sections, a communication platform to support appropriation processes should relate to the fact that the general topic of the discussions is technology (software artefacts) and its usage. It should be easy to describe all configurations and processes that illustrate current or desired usages. Furthermore, the heterogeneity of the infrastructure of the different participating individuals and organisations let us search for a web-based solution for the necessary communication platform. For basic socialisation support it should offer the use of Avatars and other graphical information about the participants, it should provide a secure authentication of participants and allow different styles of expression (e.g. by means of text formatting, additional

external URLs etc). The reference to technological visualisations and illustrations attached to an articulation should be visible directly, not just after opening a link. Aside from these considerations the requirements mentioned above also had to be met.

We decided to use a professional web-based forum software named Burning Board<sup>5</sup>, because it supported the direct visualisation in a way that was easy to combine with the support for “quoting” software artefacts that we wanted to offer (see below). The platform also provided typical functions like polls, Emoticons, reader’s evaluation of contributions, searching a forum, etc.

We added to the forum platform an entry webpage, and configured additional forums beside the actual workshop forum to allow additional interaction:

- a “self-introduction” forum which provided an opportunity to describe interests and motivation to participate,
- a “support” forum for questions regarding the technologies used in the online workshop,
- a “Concept & Critique” forum to allow for discussions about the concept of the online workshop as a whole,
- a “Current Problems and Questions” forum that was supposed to give room for questions regarding the current implementation of the component-based framework,
- a “Test” forum for trying out the tools, and
- a “General” forum for off-topic discussions

Documentation on the purpose of the workshop and the history of the workshop idea was provided in an additional forum. The three actual workshop forums related to the workshop concept described in the next subsection. In addition to the forums, email was used to advertise the workshop and to provide summaries. Figure 1 shows a screenshot of the environment.

### 3.2.2 Providing Process Guidance and Facilitation

A concept for process guidance in an appropriation process has to address several problems. Appropriation usually happens during, but also as a side issue of the “real work”, and is usually not a focal point of attention. Progress and intensity of the related activities are usually driven by needs and constraints the appropriating actors feel during their everyday work. However, if the software under appropriation is a collaborative one, there is some coordination necessary, and a structure to visualize progress and keep focus may be helpful. At the same time, every structure has to be flexible and negotiable to be adapted to the current work situation in the group.

Explicit support for an appropriation process should facilitate the reflection of current work practices. The nature of appropriation as a side process may need to

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<sup>5</sup> <http://www.woltlab.info/>

be addressed by the facilitation of a moderator to keep the discussions alive, and by the facilitation of an editor who summarises the discussions in a way they can easily be accessed by participants who dropped out of the discussion for a while.

For process guidance, a compromise had to be found between giving the discussions enough structure to allow a transparent and converging negotiation process and providing enough freedom to allow participants to freely articulate their needs and preferences. We decided to give the discussion only a coarse structure. The basic idea that inspired our concept was the “Future Workshop” concept developed by the Austrian future researcher Robert Jungk (Jungk and Muellert 1996) who was inspired by the “Brainstorming” method that Marketing specialist Alex F. Osborne developed in the late 1930s. At its core, the “Future Workshop” method describes a creative discussion and decision process that proceeds in three phases:

- A “Critique” phase, in which the participants criticise the existing problem situation without the necessity to provide a “better” way how things should be. The idea is to generate a holistic description of the current problem.
- An “Idea Creation” phase, in which participants fantasize about possible solutions to their problem and possible ideal states of their situation without considering existing limitations and resources. The idea is to describe a rich spectrum of possible directions and goals in the current situation.
- A “Realisation” phase, in which the ideas that have been generated in the second phase are tested against the available resources and decisions are taken for a realistic next step and for a plan achieving that goal.

The process is usually only the framework for further methods to foster creativity. These are, however, difficult to transfer to an online concept because of the asynchronous and distributed nature of the communication in our setting. The concept already has some tradition as a method for software design (see Kensing and Madsen 1991), We implemented these phases as discussion forums in the communication platform we provided. The timeline we planned suggested three weeks for the “Critique” phase (to also allow latecomers to join in the workshop), two weeks for the “Idea Creation” phase, and three weeks for the “Realisation” phase. We also planned for a continuation of that forum as an accompanying measure for the tailoring of the infrastructure. It was clear that the timeline had to be adapted to the organisational needs that would occur during the course of the workshop.

Between the phases we planned only a one or two days for editing a summary and compilation of the contributions, sending it to all potential participants, and to allow people who did not participate in a phase to react to its results. Aside from that the facilitators also should frequently e-mail additional information about the ongoing activities in the workshop to all potential participants.

We suggested that every new participant should introduce himself or herself in the “self-introduction” forum by describing his or her interest in the workshop topic. Complementing this we planned for a start the event with a brief face-to-face “introductory workshop” to allow participants to introduce themselves to each other and socialize. We planned to describe workshop technology and purpose, and to react to first reflections of the participants regarding the concept.

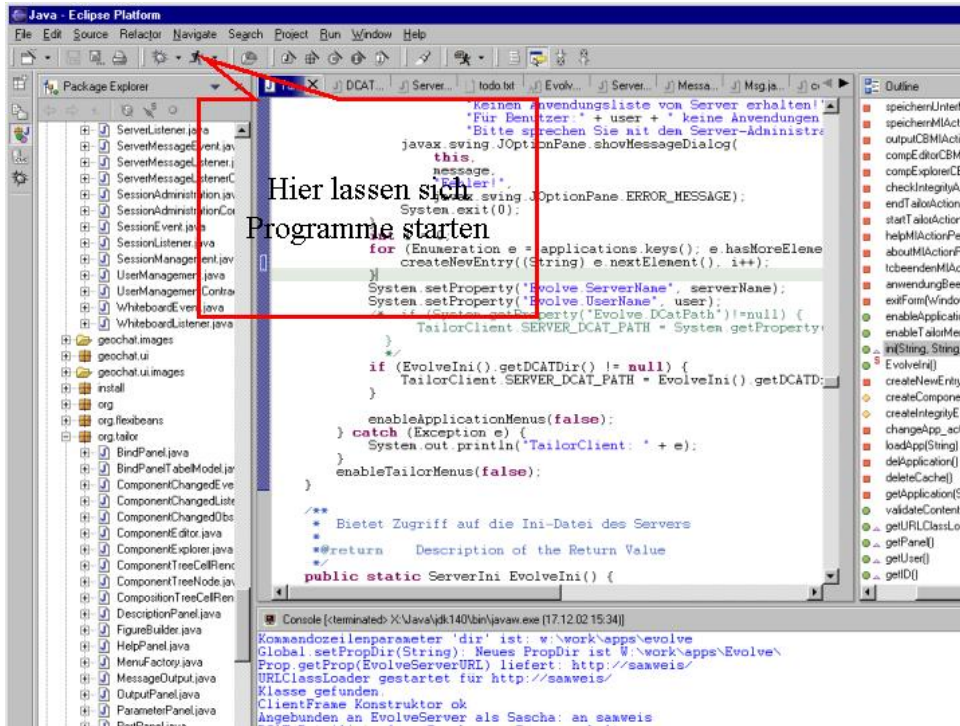


Figure 2: An annotated screenshot created with the tool for quoting software

### 3.2.3 Supporting technology-related articulations

To support the communication about and demonstration of software, configurations and usages it is necessary to integrate visualisations and references into a discussion process regarding the shared usage of an infrastructure. We partly addressed that need already when deciding for a communication platform, where we chose a product that was able to accept and display graphical contributions and to refer external material by URL.

However, the concepts that we collected in the “Supporting Online Conversations” section suggested a higher level of integration between discourse and topic representations. Many of the approaches integrated the discourse into a tool representing the artefact. Regarding appropriation support, we also followed that approach in Pipek (2003). However, for the problem of tailoring an infrastructure this is not possible since there is no uniform “topic representation”. Therefore, we followed a discourse-centric approach here, but still felt a strong

need to ease the integration of “topic representations” into the communication process.

When discussing software, the initial “topic representation” is what we can see from the software (although additional representations of architectural aspects, navigation concepts, etc., also may make sense). For that reason we provided an additional tool to easily integrate annotated screenshots as a contribution to the discussion in the forum.

Since all participating organisations had different but similar technological infrastructures it was possible to use the similarities (Windows platform, availability of Powerpoint at all workplaces) for a lightweight support tool. Our tool consisted of a Powerpoint<sup>6</sup> macro and a management program that was running in the background. Using the tool, users were able to produce a snapshot of the current screen or window that was automatically loaded into a simplified version of Powerpoint that only offered circle, square, arrow and text as annotation options. With a further button press the annotated screenshot was saved as a JPEG-file, and the file location was copied into the operating system’s clipboard. After creating a new contribution in an online forum, it was possible to copy this location into the “attachment” slot of the “new contribution” form to produce a graphical contribution. All these steps could be performed by a knowledgeable user without our tool. But as the experiences regarding online conversations indicate, it is extremely important to make that process as easy as possible. Figure 2 shows a picture of an annotated screenshot.

## 4 Trial and Evaluation

Although our trial has to be considered a failure if we just look at whether or not the acclaimed goal has been reached, we were able to draw experiences from it regarding our support concepts as well as regarding the dynamics of intra- and interorganisational appropriation processes.

### 4.1 Evaluation Methodology

Our evaluation of the workshop concepts and the analysis of the main reasons for the workshop’s failure were informed by three different measures:

- An observation and evaluation of the workshop contributions themselves, especially regarding the understanding of workshop purpose and support measures.
- The taking of additional field notes in the author’s role as a colleague and workshop facilitator, mostly regarding organisational and interpersonal aspects that affected the course of the workshop.

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<sup>6</sup> <http://office.microsoft.com/powerpoint>

- Semi-structured interviews (Nielsen 1993) with 5 workshop participants from two of the participating institutions (after the workshop ended). The interviews focussed half on the provided support measures, half on the organisational background and dynamics that influenced the participants' perspectives and activities in the workshop. The interviews had 29 questions and took between 60 and 105 minutes.

We now describe the workshop in more detail.

## 4.2 The Course of the Online Workshop

The workshop plan was significantly postponed because of changing work schedules and workload at the different participating sites. Instead of an anticipated 10 weeks, the workshop took about 20 weeks (including interruptions see below) until it was abandoned. It did not produce the desired result, but at the end of the workshop also the need for a shared infrastructure was not there anymore. The countable outcome of the workshop was some documents with proposals regarding inter-organisational software documentation. So, evaluated strictly regarding the intended outcome, the workshop has to be considered a failure. We will later come to a deeper evaluation of our experiences, but now just start with a description of the events.

The author took the responsibility for workshop facilitation regarding concept- and content-related issues, a second facilitator specialized on technical issues. During the workshop, 18 of the potential 28 participants logged into the workshop system, but only 12 participants belonged to the core group driving the discussions. Altogether, 105 contributions were written on 54 topics across all discussion forums.

### 4.2.1 Start and Critique Phase

The Online Workshop started in December 2002, and since around the Christmas holidays there was a lowered attention anticipated, the Critique phase was given five weeks instead of the initially planned three weeks. Since an earlier date was not available, the initial face-to-face meeting had to be postponed into week 3 of the workshop. The facilitators tried to compensate that with an intense advertising of the workshop to the potential participants. They also requested for a self-introduction of participants, and 9 participants put a description into the according forum. The face-to-face meeting, where 19 of the 28 potential participants met, did not significantly affect workshop participation.

In this phase, 82 messages have been posted in 38 Threads. About half of them dealt with details of the workshop itself and related to problems with either the technology or the concept of the phases. The contributions regarding the workshop goal distributed evenly into contributions regarding the problems with the component-based framework in its current state, discussions regarding the

tools that have been used for programming and discussions regarding organisational aspects (development process, documentation and code comments). The facilitators initiated two polls on the “Integrated Development Environment (IDE) currently used” and the “location where you are working with or on the component-based framework”.

The phase closed with a summary of the contributions being fed back to all potential participants together with a (unanswered) request for comments. The main issues have been:

- Whether or not a shared development process would require the uniform usage of one IDE, and which IDE that would be (Discussion focused on Netbeans vs. Eclipse).
- What circumstances hindered or complicated the establishment of a shared versioning system (usually CVS), especially the problem of access and synchronicity in various work contexts (work place, home, mobile access).
- How to overcome a problematic separation of application and framework code that was enforced by the framework’s architecture.
- What deficits and problems there are for establishing a coordinated development process (communication, specifications, testing, code commenting, etc.).

#### 4.2.2 Idea Creation Phase

Towards the end, the Critique phase already experienced a decreasing frequency of contributions. The research group Alpha was finishing a large project (that had no connection with the workshop or the component-based framework under discussion), in which 9 members were involved, from which 7 also belonged to the core group of active workshop participants. After some discussion inside Alpha it became clear that an immediate continuation of the workshop would not make sense. This was also discussed with group managers and workshop participants from the other organisations, and it came to an agreement to postpone the second phase for some weeks.

Further postponements resulting from similar reasons lead to a break of six weeks until the second phase was started. By that time, Gamma had refocused their development efforts, and the component-based framework now just played a subordinate role in their plans, although the participants of Gamma wanted to remain as observers in the workshop.

Since we expected the workshop re-launch to be problematic because of the long break, we planned 4 weeks for this phase and increased the advertising of the workshop. In the second phase, 15 contributions in 5 threads were posted by 6 people. About half of them related to the workshop scheduling and the results of the Critique phase, the other played with ideas for the appropriate IDE. However, in several (face to face and telephone) discussions with workshop participants it

became apparent that most of them did not see the benefit of an “idea creation without consideration of resources” since it was “clear that we will not develop a new IDE” (workshop participant). Two participants said that they would explicitly skip the idea creation phase to join in the discussion again in the Realisation phase.

#### 4.2.3 Realisation Phase

The spring vacation time lead to an anticipated delay of three weeks in the start of the final phase. Although it was foreseeable that the phase would take the time that was needed to establish a shared infrastructure, the facilitators thought it would be important to set a deadline to aim for, and the phase was announced to last 4 weeks.

The facilitators started the phase by advertising it, distributing again the results of the prior phases and initiating 10 polls to prioritize topics and to ease the start of the discussions. The 13 contributions to 11 topics were mostly statements of two very active participants that related to the poll issues and remained unanswered.

Further requests to participants that were active earlier revealed that two incidents had significantly influenced the shared interest into the component-based framework. In the cooperation between Alpha and Beta, the distribution of tasks had been re-negotiated with the result that development tasks shifted from Beta to Alpha, leaving Beta with almost no direct interest into the shared infrastructure. Also, the application of Alpha and Delta for research funds was declined. In addition to that, even within Alpha two groups started focusing on different aspects of the further development of the framework, which lead to separate development processes and code bases a few months later. The workshop did not come to a formal end.

### 4.3 Workshop Evaluation: General Aspects

Before we analyze the aspects of online discourse, future workshop concept and work organization as critical points in the failure of the workshop, we want to address some general issues regarding appropriation and appropriation support that arose from the observations and interviews.

#### 4.3.1 Background of the interviewees

Before we comment on the workshop itself we want to briefly describe the background of the interviewees, as it illustrates their judgement on the experiences made. From our observations, the interviewees represented the average workshop participant well.

The interviewees were students in or staff members of the organizations involved. They all belonged to their organizations for more than 10 months (and

up to 5 years), had an education (ongoing or with a masters degree) where computer or information sciences was at least a minor subject. They had computer and Internet experience of at least 10 years, and all had already made experiences with computer-mediated communication in Mailing lists, Usenet newsgroups and/or web-based forums regarding private as well as professional issues.

They were also used to administrate and configure large parts of their computer-based infrastructure on their own, and all had already asked for technical solutions or support in online discussion forums. However, they approached the management of their technological infrastructure differently; some were more exploratory and experimented with new devices, software and software configurations, some were more reluctant and only did the “necessary” things. Consequently, the time they spent for tailoring their infrastructure was reported to be between 30 Minutes and three hours a week.

#### 4.3.2 Evaluation: Results vs. Effects

Although the workshop had no *result*, it had an *effect* on the work environments of the participants. During the course of the workshop the use of Eclipse as a development platform spread, and within Alpha there were experiments with a local CVS installation. Three examples from the workshop discussions document the description and transferral of usages:

“The only important drawback [with Eclipse] is the missing GUI editor. <...> I use NetBeans still as a GUI editor. You can use “copy and paste” to put the code into eclipse. That’s not very elegant, but it works fine.” (Ivo, Participant from Alpha)

“From my point of view, considering the current state of development [of the Netbeans IDE], it would be wise to use Netbeans (Version 3.4 or later), especially because of the support for XML, the existing GUI editor and the ‘pure Java’ concept. To have a more comfortable coding environment, I will use the Eclipse editor, and work with the ‘mixed solution’ Ivo suggested. To produce UML diagrams, I use TogetherJ ControlCenter 6.0.1 [another IDE previously not discussed] at home.” (Edmund, Participant from Alpha, in reply to the message above)

“BTW: Thanks for the hint about Ctrl-Space and Ctrl-1 in Eclipse. I didn’t know that, and it is very useful!” (Participant from Alpha in reply to a practical comparison between Eclipse and Netbeans another participant from Alpha provided)

Local documentation guidelines developed from the discussions, and although no actual cooperation projects were established, a large interest in the concepts, use and further development of the component-based platform remained. Also, the understanding of the remaining problems and challenges for the component-based platform were said to have deepened. These developments were described by interviewees as clearly associated with the workshop.

In general, the interviewees and further workshop participants remained with a positive attitude towards the workshop, although quite some criticism arose regarding some details of the concept (see below). They valued the workshop as an opportunity to reflect work practices, and to learn something about tool usages

of colleagues. The workshop (and the platform) was not always the communication medium for these interactions, but rather the inducement of local (face-to-face) communication.

But also the use of the discourse environment spread because of the workshop. The workshop concept and technology was presented to three cooperating industrial partners of Alpha and Beta. One decided to use the online platform for inner-organisational discussions regarding the infrastructure (although they did neither adopt the future workshop idea nor the software quoting idea). Another company considered cooperating with Alpha to have a basis to discuss infrastructure changes, but due to a lack of funding the project did not materialize.

The experiences we made in the workshop underline the high dynamics that collaborative tool usages underlie in distributed settings. After all, the establishment of a shared infrastructure proved to be an issue whose importance to the participating organizations underwent various changes, and that, consequently, received varying degrees of dedication from the participants. For the technical support of appropriation processes this means that the support concepts have to be easy to join, easy to leave, and easy to re-join. Interviewees also underlined that it was good that the participation in the workshop did only require little preparation: registering, logging in, tool installation and reading of introductory documentation usually took less than 20 minutes.

It is also clear that the workshop concept itself underwent a process of appropriation. Neither the forums in the communication platform nor the tool for quoting software have been used for the purposes and with the same intentions as we intended. The quoting tool was also used for illustrations in email communications, and quite often questions, statements and comments did not land in the according forum, but rather in the forum where there were most of the discussion activities (see discussion of the future workshop concept below).

We now turn to the three most critical aspects of the workshop concept in more detail, but only discuss issues related to technology assessment, configuration and usage.

#### 4.4 Trial Analysis: Online Discourses about software artefacts

The general problem in a communication-oriented technical support concept for software appropriation processes is that it is not easy to actually communicate about the abstract concepts and use context of software artefacts. When asked why talking about software is “difficult”, the interviewees addressed issues like complex and diverging application ontologies, navigation concepts and architectural concepts that are all hard to express using language alone. But maybe the biggest problem is talking about missing or unknown functions, which is an inherent issue in technology appropriation. A relatively optimal communication situation was described as a mixture of communication and demonstration. The solution we provided with allowing for the quoting of

software artefacts by means of annotated screenshots was estimated to be an acceptable approximation of that scenario. It was stressed that it is necessary to be able to produce these quotes very spontaneously in a problematic situation. Interviewees rose the idea of using annotated “screen movies” to represent dynamic aspects of tool usage, but also saw problems regarding the costs of authoring a statement. But alternative base material regarding the software artefacts under discussion, like architectural drawings, navigation path visualisations, manuals or other documentation were estimated to be valuable to be quoted in these discussions. However, a limited expressiveness would remain, not only regarding the difficult articulation of missing and unknown issues, but also regarding the incorporation of the broader work context of software usage (organisational structures, use traditions, cultural aspects, etc.).

Besides discussions on how to reduce the cost of contributing to a discussion there have also been comments on how to optimize the benefit of these contributions in using them as an information resource for beginners, in case of problems with a certain tool or functionality, or simply as a documentation of the evolving technological infrastructure.

Regarding the communication platform itself (and its configuration), interviewees reported it being problematic to find and post contributions in the “appropriate” forum. Two interviewees would have appreciated “argument networks” instead of fixed discussion forums, with the provision of different views regarding selected aspects of the network. One participant favoured a hybrid approach that would also incorporate frequent synchronous communication events (chats or video conferences), and two other interviewees pointed out that additional brief face-to-face meetings would have maintained a higher level of attention and involvement of participants and would have resulted in a denser communication.

But altogether, the communication platform and the support for quoting software were valued as an appropriate approach considering the given restrictions regarding time and dedication as well as infrastructural heterogeneity in an inter-organisational setting.

## 4.5 Trial Analysis: The Future Workshop Concept

While the general support for software-related online communication was appreciated, the idea of applying the future workshop concept to the appropriation process received some criticism.

First we can say that from observing the discussions it became obvious that the idea of “restricted” discussions in the different phases was difficult to communicate and maintain throughout the discussions. This might also be a problem for “real” future workshops, but the persistent character of online discussions on our platform manifested the deviations from the announced discussion style in a more sustainable way, and was more resistant to corrections.

In our case, participants started arguing about or evaluating criticism in the first phase (see dialogue between Ivo and Edmund above), and discussed contributions in the second phase (“idea generation”) against previous suggestion:

“As Viktor already said during the ‘critique phase’: It would be desirable to use only *one* IDE.” (Participant from Alpha in response to a suggestion to document a range of IDE’s and their usefulness.)

Both reactions are not desirable for a future workshop. The facilitators were criticized by the interviewees for reacting too slow to these violations of the rules, but on the other hand some of the violating contributions themselves were worth publishing in the workshop (though maybe in a different forum). At that point, technological restrictions of the platform hindered spontaneous solutions (e.g. relocating or managing the “preliminary rejected” contributions).

However, the thematic framework the phases defined was estimated as being appropriate for the process of negotiating infrastructures. But the interviewees criticised the strictness and seclusion of the phases and the problem of dealing with ambiguous contributions (e.g. when a consistent contribution described a problem as well as a possible solution). They suggested a number of alternative ways of arranging the phases or forums, e.g. allowing for several iterations through the phases, working in all phases/forums in parallel (with or without delayed start of the later phases), allowing references between contributions to different phases/forums.

Especially the “idea creation” phase received criticism since many interviewees doubted that it makes sense to “fantasize about technology without considering resources”. It is interesting that at that point, although many contributions in the Critique phase also addressed organisational aspects beyond technological considerations, the participants did not discuss desirable work situations from a more holistic perspective.

The necessity of process guidance and structure was confirmed in the interviews, although with quite a range of connotations:

“Maybe it would have been a good idea to use a ‘growing document’ instead of a process concept to keep the state of discussions transparent for all. Upon completion, this document would directly represent the solution or agreement found. Maybe a ‘mind map’ would be a good document format... Although it is quite difficult, to imagine a good representation for a complex discussion like this.” (Participant from Delta)

“It was good to have phases with fixed deadlines, though. Time pressure leads to more focus and increases ‘productivity’.” (Participant from Alpha)

## 4.6 Trial Analysis: Productive vs. Infrastructural Work

Although the immediate goal of the workshop was to align four different technological infrastructures (a “tailoring” task), it was obvious that in the broader context the issue was the alignment of four work situations and work styles. And while the configuration of a shared technical infrastructure was

considered a solvable challenge, the associated alignment of the work styles was considered much more painful. Consequently, a very careful consideration of the cost-benefit balance preceded every activity in the workshop and contributed to the degree of dedication the individuals and organisations showed. And since individuals from all participating organisations signalled “some interest” into the workshop goals even at the point it was abandoned, the perceived negative cost-benefit-balances can be said to be the main reason for the workshop failure.

The announced workshop goal suggested a rather strict separation of productive work (working in an infrastructure), and infrastructural work (configuring an infrastructure) as a meta-task. This separation was rejected in a number of ways in the workshop’s practice.

First, observing the discussions themselves showed that there was no clear line drawn between criticizing the current state of the framework’s implementation (Work level: What is that thing we work on?) and criticizing current work practices (Meta level: How do we work on it?). In two cases, very concrete problems with the current implementation were discussed (as “criticism” of the current situation) in the workshop forums, although we provided an extra forum to keep this type of discussion away from the discussions in the phases (That forum remained the only one that did not receive any contributions).

Dedication to the workshop (and to the meta-task of managing the own infrastructure) was also very dependent on the participant’s current work situations. Many interviewees argued that their involvement in the workshop would have been higher if the workshop had been more present at their workplace. They discussed a stronger integration of the web-based forums with email-based concepts, or suggested an even stronger integration with their operating system’s desktop. But one interviewee also considered it a challenge to address all technological platforms and all work styles in a setting as heterogeneous as the one of the workshop.

Further, the long breaks between the phases (and the reason for them) indicate that a strict separation between meta-work and “real” work is also not beneficial for appropriation support itself. When the workload got heavier for the majority of active participants there had to be an explicitly announced postponement of the workshop since the scheme of the phases and the existence of deadlines required an explicit handling of the situation. With a weaker support structure it maybe would have been easier to keep up some activities within the appropriation support structure even at times of a stronger focus on the productive work.

#### 4.6.1 Inter-organisational Issues

The involvement of more than one organisation added to the complexity of the issues described above. The rhythms of discussion were not really synchronous, and since Alpha had the largest number of participants and dominated the

discussions the “activity rhythm” of Alpha also dominated the workshop, which was frustrating for the participants of the other organisations.

One interviewee from Delta also complained about the problem of “lost” local discussions:

“In some contributions from Alpha it was obvious that the message did not present the complete argument, but was referring to a local discussion within Alpha. It was frustrating in two ways: I felt excluded and I had the feeling that the missing part would have been valuable for the workshop, too.”

Some interviewees mentioned that more face-to-face meetings would have mitigated the inter-organisational issues, since mutual understanding for such unconscious discrimination and trust regarding the general intention of all to have fair discussions would help keeping up the motivation at all sites.

## 4.7 Evaluation Summary

Our approach to appropriation support in the concept described here was to support the technology-related communication between users and to support the demonstration of usages. It was an implementation of our idea of “Use discourse environments”. The anchor for the support we offer is where tailoring and configuration activities happen. Extending the support for these activities by providing additional communication and demonstration means was considered a valuable idea by all interviewees.

Especially the provision of a “home” for the user-user-interaction regarding the appropriation of technologies and work styles (by providing a communication platform) and the efforts to ease the reference to functional details of the technologies (the “quoting” of software) were valued by the users. Even stronger:

“I think that the true value of the software quoting tool was that it made clear that it can be valuable to use annotated screenshots in this kind of discussions.” (Participant from Alpha)

“I can’t say that the communication platform provided any specific quality. It was good to have a place to discuss these issues, but maybe any communication platform would have done.” (Participant from Delta)

However, despite these opinions the course of the workshop underlined that a careful design of appropriation support is crucial.

The tension between productive and infrastructural work enforces that any support for infrastructural work has to be as efficient as possible, easy to use and open for spontaneous fluctuations of activity. In that respect, our idea for process guidance encountered difficulties, and should be revised in several ways. In a complex structure like the “Future Workshop”, a much stronger facilitation is necessary to keep the discussions going on and focussed (e.g. regarding the purpose of the phases). Maybe less sophisticated discourse structures would have produced more vivid discussions, and would have led to fewer interruptions. But facilitation also needs more flexible discussion tools that allow e.g. to restructure a discussion, decline or delay contributions and to provide easy ways to articulate

(In our case, the polls have been quite successful in producing quick overviews on the general mood of participants regarding a specific question). These results in facilitators becoming “editors” of the information provided by the participant’s contributions (and – as some interviewees suggested – maybe also relevant external information, e.g. regarding updates or new technological features).

But also the contrary approach was mentioned as one interviewee suggested to treat appropriation activities more as work tasks and supporting it with usual collaborative tools like shared calendars, shared agendas, etc. But in our eyes the dynamics we observed would result in such appropriation support tools being abandoned if there is not a strong interest pushing the process.

It became also clear, that a concept for appropriation support is also subject to an appropriation process that is driven by the users. Some of the provided concepts or tools will be not used at all some will be used in an unforeseeable way.

## 5 Discussion

We now want to take a step back, and compare our experiences to experiences that have been published earlier. In our considerations we distinguish between technological aspects of possible appropriation support concepts, and organisational aspects.

### 5.1 Technological Support for Appropriation

The concept and ideas we presented here went beyond current approaches to support “Design in Use” in not only addressing tool flexibility and the manageability of configurations (as it was the focus in the previous work on tailoring), but also additional ‘appropriation activities’ of user-user-communication (and –negotiation) and demonstration. We now discuss the results from our study against other relevant experiences.

#### 5.1.1 Support for Demonstration and Negotiation

As we pointed out earlier, our focus to technological support for appropriation as a collaborative activity lies on allowing for demonstration and discourse regarding existing and possible uses of technology. However, the approach we described carries some similarities with concepts and experiences that have already been published.

In another prototype (Pipek 2003), we implemented a discourse-oriented tailoring environment for the event notification service of a standard groupware product. In the evaluation here several issues occurred that we have been able to address there:

- *Integrating appropriation discourse at the desktop*: Several interviewees in our trial complained about a lack of integration of our workshop concept into their ordinary desktop (resulting in a lack of dedication). With the earlier prototype, the desktop to work with was provided by the groupware product, and we embedded the discourse environment into the desktop at the place where other tailoring activities also could be started. This extension of the tailoring facilities into a place for reflection and negotiation was more present during ordinary work, but this was possible due to the monolithic approach the groupware product enforced on users by providing “the” desktop for organizing documents as well as for messaging. In a multi-tool, inter-organizational environment as we encountered it, this would only be possible if we could rely on appropriate functions at a lower level (operating system, etc.). However, the fact that a lack of integration was mentioned here confirms the importance that issue has received in the earlier prototype.
- *Application ontologies*: One of the difficulties mentioned to be relevant when discussing the shared use of technology was the need to understand the different “ontologies” that applications use to describe their functionality and use. In our earlier prototype we were able to address that issue by providing a natural language representation that was derived from the metaphors the groupware product provided and the relations between objects in that groupware environment as they were mentioned by users talking about the use of that groupware. Those representations allowed an easier access to the actual meaning of a configuration under negotiation. Again, that problem is much harder to address in the technological infrastructure that we encountered in the setting described in this contribution.
- *Software quotations*: The idea of supporting an easy quoting of the technical configurations under discussions was also implemented in the earlier prototype. There our support could be much more specific, we allowed an easy citation of the natural language expressions that represented (part of) the formulas that allowed or denied event notifications. We were at the level of the application logic. In the heterogeneous infrastructure we encountered here, we were just able to support the quoting of visible representations as they are provided in the original implementations of the applications involved (by means of screenshots). This might be a disadvantage, since invisible, but relevant parts of the application logic still have to be circumscribed to bring them into the discussions, but in the trial here we were able to prove that this feature is much appreciated by end users.

Kahler (2001a) described in an approach to support collaborative tailoring with a text processor an environment to exchange tailoring objects (such as menu

structures, macros or toolbars) among a group of users in an organisation. These tailoring objects also could be annotated to describe or illustrate possible uses of the tailoring object, but this support was not intended to be the platform of user-user-interaction regarding the use of the objects. It was also not necessary, since there were no close technological ties between the users that would force them to agree on a specific configuration before collaboration activities can start. But this is the case in the scenario we described here (as it was in the scenario in Pipek 2003). However, the approach that Kahler described already was a big step to support the “proliferation of usages”, and could easily be extended to focus stronger on the description of use situations that would help the appropriation of the text processor for different use situations.

Dourish (2003) observed appropriation phenomena with a flexible, end-user modifiable document management system to derive design requirements for appropriation-friendly collaborative systems. The system broke up the traditional setting of document, application and activity by suggesting a hierarchy-free, property-based, document-centred information system. Properties could be also dynamic (defining document-based action), and the system supported private as well as shared perspectives. From the application of the system in two organizations he derived three design principles for better appropriable systems:

- *Supporting multiple views on information* to allow every user to establish the individual meaning a document has for her,
- *Preserving visibility* of possible actions as well as resulting effects to allow users to understand the information system, and
- *Making information sharing an application matter rather than an infrastructure matter* to allow for fine-grained information distribution schemes that easily can be adapted to the current work situation.

We can fully subscribe to these principles as manifesting important prerequisites for appropriable systems, but they do not explicitly address support for the moment appropriation happens. Inventing and transferring usages involves the transfer of meanings, the learning and understanding new actions to achieve new results and establishing appropriate information sharing structures, but according to our experiences (Pipek and Wulf 1999, Törpel et al. 2003) these are highly communicative and collaborative activities that are not explicitly addressed or supported in Dourish’s perspective. However, we believe that in his approach the problems we had with the ‘infrastructure’ perspective (tailoring/appropriation beyond one tool) would not occur.

In the approaches described above, some kind of annotation was available to the users to communicate meaning and use of objects. In contrast to our approach, their support did not directly address user-user-dialogue as a basis for collaboration regarding the invention and transfer of usages. Following our results, we believe that this kind of support is a new quality in the context of the appropriation of collaborative software.

Supporting communication is an explicit goal of Morch and Mehandijev (2000) in their extension of current tailoring environments. However, they do not address user-user-communication to allow for mutual understanding of configuration and usages, but focus on the long-term communication between application designers and tailoring users. In their approach, two aspects are underlined:

- Providing *multiple representations* of the concepts and functions a software offers to support the highlighting of different aspects or different abstractions of its usage.
- Providing *application units* as concepts to manage the complexity of applications by grouping representations (and functionality) into separate building blocks that become the subject of tailoring activities and related communications.

A weakness of their considerations is in our eyes the focus on user-designer communication, and the dominance of the communication direction from designers to users in their discussion. But their observations regarding the usefulness of representations is a valuable contribution if we think to extend our “software quoting” facilities. Finding appropriate (groups of) representations is important to reduce the complexity of the discussions about the reconfiguration of technology. Fischer earlier (1994, 2002) described principle and several experiments with domain-oriented design languages and representations to address that issue. We relied on self-regulating dynamics of the groups involved, since we could assume a certain shared background regarding organisational structure, education and tasks. But establishing a mutual understanding and a shared language might be much more problematic in other application fields. Then, the design of language and representations to use might have to be addressed more sincere, and simple visualisations like screenshots might not be sufficient anymore.

Twidale and Nichols (1998) showed an example for this support regarding the definition of successful search queries for a library database system, although because of the lack of persistence (of communication partners as well as “tailoring objects”) in that solution their system does not follow the notion of “tailoring” we had established here. But in their system design as well as their evaluation they also stress the importance of adequate representations (which are, in their case, visualizations of a query and the related search process of the database system) of the system’s behaviour not only for understanding, but also for communicating about a technology. Consequently, they also offer an embedded support for user-user communication.

Sticking towards our domain of collaborative software artefacts, we can learn about possible extensions of discussing usage beyond annotating screenshots from Baecker (2002). He described five more dynamic methods to “show” software usage instead of “telling” about it. However, the pessimism he shows

about software documentation professionals appropriating these methods (due to a lack of time) does not leave much hope for adopting these approaches to our context. Our interviewees already have been extremely concerned about cost and benefit of authoring a contribution in the simpler “screenshot” case.

The interviewee’s remarks regarding the reuse of communication threads for teaching novices or for the documentation of tailoring activities also lead us to the idea of working with “Use Rationales” similar to the concept of “Design Rationales” (Moran & Carroll 1996). Especially Fischer et al. (1996) discussed the aspects of uniting the purposes of documentation and argumentation.

Beyond supporting interactive demonstration and communication there might also be more indirect ways of transferring usages in organisations to support the appropriation of software. Linton (2003) demonstrated in his OWL system, how data on the usage of a word processor can be collected and presented to stimulate the usage of software functions. The heavy use of a function by “peer users” results in a recommendation for a target user who “underuses” that function. The idea is presented in a very raw state, and to find out for what kind and granularity of “function” of a collaborative application, and what kind of “peer groups” that recommendations hold, is still an open issue. But this might be an interesting idea in further developing appropriation support, as is the extension of “awareness services” (Sandor et al. 1997, Schmidt et al. 2002) from a document- and project-centred perspective with a usage- and technology-centred perspective. These observations of other usages might again result in representations that would be relevant in reflecting and discussing software usage.

## 5.2 Organisational aspects

Aside from the technological considerations, we have also gained experiences regarding the organizational and social aspects for appropriation support.

### 5.2.1 Opportunities for reflection

The peripheral character of appropriation activities remains to be the major challenge for an explicit support of users on their way to make sense of a technology. This observation confirms the organisational issue of accountability for the additional work that the communication media used pose on the contributors, as described by Zuiderent et al (2003).

With the careful consideration of cost and benefit of the investment that precedes a participation in such an “organised reflection”, we may have to provide access to communicative appropriation support measures in situations, where participants already have a strong interest in turning to the meta-level of their work. This might typically be in the case of a breakdown of work routines (for technological reasons, because of a misunderstanding in work coordination, etc.), in the case of an incongruency between the expected and the delivered value

of a tool or technology, or in case of a need for support (e.g. when pressing the “F1” button for help). We already followed that idea in taking tailoring interfaces as an anchor for appropriation support in Pipek (2003).

It is also interesting to find additional situations for usage-related reflections, which may be not or only partially technologically supported. Hansson et al. (2002) gave examples how user meetings a software development company arranged to foster the communication between users and developers also resulted in the exchange of use experiences among users.

### 5.2.2 Future Workshops in Appropriation Processes

Summarizing our experiences with our way of providing process guidance and facilitation, the concept of the Future Workshop does not fit well with the varying degrees of participant dedication and activity. However, we have to consider that the concept usually is a frame for further, activity-related creativity techniques, and that our concept of “quoting software” (as the major supporting concept) surely was not able to substitute these techniques in an online environment. Cox and Greenberg (2000) used a kind of online creativity technique to support collaborative interpretation that might be interesting here.

There are several initiatives in Germany that experiment with Online Future Workshops in other fields (e.g. regarding the future of linguistics<sup>7</sup>, regarding school development<sup>8</sup> and regarding Gender Politics). New improvements regarding the virtual environment in which an online workshop takes place might again alter the perceived imbalance of cost and benefit of that methodology.

### 5.2.3 Framing conditions of Appropriation Support

With our ideas of offering technological support for appropriation activities we have to consider carefully how far our ideas carry. In earlier studies we have been able to show examples how usages have been transferred or developed:

- By handing over a readily installed laptop, a certain organization of personal information was transferred between a senior member of a company and a novice (Törpel et al. 2003).
- By discussing a pile of forms on a desk, a staff member and a member of an IT support group started developing a groupware-based version of a coordination process that significantly improved process speed (Pipek and Wulf 1999)

Though these examples illustrate “demonstration” and “communication” as important activities to transfer and discover usages, they also illustrate the existence of framing conditions that allowed the activities to succeed. In the first example, a certain basis for trust had to be established to allow before it was

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<sup>7</sup> <http://www.editiv.de/>

<sup>8</sup> <http://www.zukunftswerkstatt-online.de/> (in German only)

acceptable to hand over a laptop computer still containing most of the documents the previous owner had worked with. In the second example, the IT support members were active in the field since there was an acclaimed effort to develop computer-based work processes for this authority. That gave the freedom to discuss and implement changes.

These are just examples; further beneficial framing conditions could easily be extracted from the examples. In our case, the existing personal bands between the four organisations also contributed significantly to the relative success of our trial. We have to be aware that despite more elaborated support for the exchange and negotiation of usages, the dog still wags the tail, not vice versa: An open communication culture and a basic organizational interest in improvement and reflection are prerequisites for successful appropriation. In that respect, further research will also have to find out what kind of appropriation support measure is appropriate for what kind of organisational setting.

## 6 Future Directions of Research

Our research focuses on the “user” end of the production line of organisational software development, and on the creative activities performed by users to shape new usages, appropriating available technologies for the respective work environments. We believe that tools and tool infrastructures can be better prepared to support or at least facilitate these activities already at the “designer” end of the production line. The idea of ‘use discourse environments’ to facilitate an integrated online communication on tool usage and configuration has been explored in two prototypes (Pipek 2003 and this contribution), but more experience with supporting appropriation processes is needed to identify the relevant aspects for different application fields. Our research focused on mutual representations of the artefacts in the discourse and of the discourse in the artefacts, and on ‘process guidance’. But maybe we benefited from the already established ‘design attitude’ in the four participating organisations, and maybe the establishment of this attitude would be the central problem in other application fields, and a stronger focus on explaining possible tool modifications would be necessary there. More experiments with ‘use discourse environments’ or other ideas for ‘appropriation support’ are necessary to better understand the dynamics at work.

However, we consider it important to leave a pure analytical perspective on appropriation-in-practice phenomena behind, and experiment more with different ideas to improve the awareness and the support of possible ‘design’ activities in use situations. On the one hand, ‘tailoring environments’ have only been a start of a new kind of tool functionality to support these activities that we address as ‘appropriation support’, on the other hand the use of this functionality could also

help rendering visible the ‘invisible work’ of technology appropriation, and thus ultimately lead to a better understanding of appropriation phenomena.

## 6.1 Reconsidering ‘Infrastructure’

One of the crucial problems of appropriation support is, according to our experiences, to understand and to deal with the subordinated nature of ‘infrastructural’ work compared to ‘productive’ work. Latest discussions on ‘infrastructuring’ may provide an interesting perspective for these problems.

As it can be seen often, we used the term “infrastructure” throughout the paper in a usual, but rather light-headed manner to address a connected multitude of technologies, tools and devices that we usually encounter in organisational settings. Star and Bowker (2002) analysed history and relations of traditional “infrastructures” like water channel systems and electrical power systems, and the consequences this should have for technology design. They described seven features that constitute the character of a structure that is perceived as an “infrastructure”.

The tension between proliferation and standardisation for holistically recognising appropriation practice can be captured in this framework by the explicit consideration of the spatial and temporal scope of infrastructure and its usage, and by addressing the duality of the “global” nature of infrastructures and its local practice.

When we discuss collaborative software as a specific type of work infrastructure (as it already was one of the intentions in Star and Ruhleder 1996, and as it is the main perspective in Karasti and Syrjanen 2004), we can use it to find and acknowledge situations where the line between “productive work” and “infrastructural work” is “naturally” crossed. This might be e.g. in cases of an “infrastructure breakdown”, no matter whether there is an actual breakdown or “just” a perceived failure (expected service not delivered by infrastructure). These situations may be those, in which measures of appropriation support may receive more attention since the productive work already has been pushed into the background. Many studies of the work in “technology-use-mediation” (Orlikowski 1992, Okamura et al. 1994, Trigg and Bødker 1994, Mark 1997) also illustrate that user support in “breakdown situations” contributes to a better technology understanding. With the “conflict detection” feature in the an earlier prototype that implements our “use discourse” idea (Pipek 2003) we were able to raise attention in a very specific breakdown situation (“A tailoring activity has been initiated that conflicts with my individual settings”). To follow further these considerations may improve the understanding on the dynamics of appropriation processes.

## 7 Conclusion

Latest theoretical (Suchman 2002) as well as practical (Dittrich et al. 2002, Törpel et al. 2003, Karasti and Syrjänen 2004) considerations called for overcoming the old design-use-dichotomy of software development, and for improving the awareness of ‘located accountabilities’ in technology production and use (Suchman 2002). In this contribution we focused on “user” accountabilities, on the ‘appropriation activities’ that are performed at the “user” end of the software production line, and that significantly contribute to framing a successful usage of collaborative technologies.

We addressed the design of concepts that help users of collaborative software products to appropriate the technology for their needs. One basis of our thoughts was the observation that activities of demonstration of and discussion about technology significantly contribute to distribution and innovation of technology usages. We extended the classical idea of “tailoring interfaces” that support the flexible configuration of technology in use situations (and thus “continuing design in use”) towards ‘use discourse environments’ that also support activities of demonstration and discussion (or even stronger, negotiation) at the “user” end of the software production line. As an example for this idea we presented a prototype and a field study of an “Online Future Workshop” to establish usage and configuration of a collaborative software development infrastructure between four research organizations. We provided a web-based communication platform, support for process guidance (facilitation, future workshop concept) and easier articulation of technological aspects (software quoting). Though the online workshop in our study was abandoned and did not reach the intended result, the critical analysis of its course allow us to evaluate our concepts and achieve deeper insights regarding the creative dynamics of software appropriation, and possible support concepts.

On the positive side we can say that the general ideas of “Use Discourse” (to give a “home” to discussions about the use of collaborative software and to provide specific support for technology-related articulations were considered valuable by the participants of the workshop. They also associated the spreading use of a programming platform and of a versioning tools with the discussions in the workshop, so we could see that usages actually have been transferred and invented in our concept. Although workshop participants confirmed that some form of process guidance and transparency is helpful for this kind of appropriation activities, the concept of the ‘future workshop’ was criticised as being inflexible and not necessarily suitable for more technological issues. However, the tension between primary work tasks (“productive work”) and the “infrastructural work” of appropriation activities (as subordinated tasks) proved to be the crucial problem for our appropriation support ideas in the “Online

Future Workshop” experiment. This tension leads to varying degrees of dedication and involvement of participants in the online workshop.

On the technological side of our research, we aimed at supporting demonstration of and communication about usages. But when we think further these ideas, a perspective on application development evolves, in which “appropriation support” becomes a cross-sectional issue of application design as “help systems” are already today. Research aspects we discussed in the “Supporting Online Conversation” section also showed the value of integrating discourse and issue (representation). An application would provide hints on observable usages on the functional as well as the organizational level (with the help of additional infrastructures), and access to interactions with other users regarding use aspects (discussion, negotiation, exchange of configurations). Applications could be ‘populated’ by their users, and these would form an online community of practice regarding application usage.

On the organisational side, we can say that there is a string need for facilitation to cope with the varying degrees of participant involvement. We could well imagine that future concepts would incorporate the role of an “Appropriation MC (Master of Ceremonies)” as an important part of appropriation support measures. Since appropriation will remain a side task in most work environments, this might be the solution that comes next to the ideal solution that appropriation support would change accordingly just upon users acting differently.

Our study contributes to a growing body of studies that focus on the creative aspects of ‘using’ technology, on design in use. We believe it is important to go beyond an analytical perspective on appropriation phenomena. On the one hand, the support of these activities can become an important aspect of designing the technologies themselves, on the other hand support approaches like the one described here help render visible the ‘invisible work’ appropriation activities constitute, making this type of work also more accessible for an analysis of the dynamics at work. In our account of future directions of research, we did not only call for more experiments like ours to better understand appropriation activities, but also addressed the current discussion on “how to infrastructure” (Star and Bowker 2002) as an important perspective establish ‘located accountabilities’ and to understand their relations.

We consider our perspective of Appropriation Support as a contribution to an agenda to change the foci of technology design:

“Our agenda ... is to bring developing objects out into the environments of their intended use, such that their appropriability into those environments becomes a central criterion of adequacy for their design” (Suchman 2002, p. 99).

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