Technology for Boundaries

Susanne Bødker, Jannie F. Kristensen &
Christina Nielsen
Dept. of Computer Science, University of Aarhus
Åbogade 34
8200 Århus N, Denmark
bodker, jannie, sorsha@daimi.au.dk

Werner Sperschneider
The Mads Clausen Institute, University of
Southern Denmark
Grundtvigs Allé 150
6400 Sønderborg, Denmark
sperschneider@post-tele.dk

ABSTRACT

This paper presents a study of an organisation, which is undergoing a process transforming organisational and technological boundaries. In particular, we shall look at three kinds of boundaries: the work to maintain and change the boundary between the organisation and its customers; boundaries between competencies within the organisation; and boundaries between various physical locations of work, in particular between what is done in the office and what is done on site. Maintaining and changing boundaries are the processes through which a particular community sustains its identity and practice on the one hand, and where it is confronted with the identity and practices on the other.

The organisation being studied employs a multitude of IT systems that support and maintain these boundaries in a particular manner that are in many ways inappropriate to the current needs of the organisation.

After analysing the history and the current boundary work, the paper will propose new technological support for boundary work. In particular the paper will suggest means of supporting boundaries when these are productive and for changing boundaries when this seems more appropriate. In total, flexible technologies seem a core issue when dealing with technology for boundaries.

Categories and Subject Descriptors

H.5.3 [**Information Interfaces and Presentation**]: Group and Organization Interfaces—*Computer supported cooperative work, evaluation/methodology, organizational design*

General Terms

Design, Human Factors

Keywords

Boundaries, CSCW, IT systems, mobile technology, nomadic work

1. INTRODUCTION

In this paper we focus on boundary work as the key to understanding working relations in organisations, as well as to developing and using information technology within the organisation. We have been inspired by the concepts of boundaries and generative reasoning, as advocated by social anthropologist Fredrik Barth [1]. The point of Barth's argument is a perspective that cares for processes at work, but not for causal relations. Instead he is concerned with contexts and situations in which boundaries are generated. Barth wants us to focus on boundaries and boundary work rather than

> "on the cultural stuff that it encloses" ([1], p. 15).

The focal point of his claim is that it is the boundary that defines the group rather than the cultural core. Organisational boundaries become visible in organisational structures and rules, and they exist as invisible patterns between individuals and different groups of people. Boundaries, for example, separate one work domain from another, and one profession from another, or they can be drawn between groups of people defined by shared interests in for example new technology. Boundaries encapsulate the identity of the community. Boundaries are marked because communities interact with entities from which they are, or wish to be, distinguished [1]. The manner in which they are marked depends upon the specific community: administrative boundaries may be statuatory; cultural boundaries may be marked by language, habit, custom, etc.. However, as pointed out by Cohen ([7], p.12), not all boundaries are so objectively apparent. They may exist primarily in the minds of their beholders, and hence, the boundary may be perceived in rather different terms by people on the same side of a boundary. We have chosen this perspective in order apply a dynamic perspective on technvlogy with respect to its role on the boundaries, which we will return to later.

This paper presents a project in which the key focus was on studying and supporting mobile and nomadic work for a group of architects and engineers working as area managers at a County Construction and Energy Consumption Office (C&E). The research areas of mobile and nomadic computing are closely linked, and the terms are often used interchangeably. They are both referring to views and descriptions of new ways of working, enhanced by recent developments in information technology and pervasive computing. In general, the term mobile emphasises the difference between mobile and stationary work as an important

concern in relation to design of new information technology devices, and it often focuses on the role of the individual worker/user. The term nomadic is more elaborately focusing on contemporary work conditions as a whole, focusing on transitions between different work situations, between collaborators (collaborating ensembles), and between computer support in webs of technology regardless of whether the user is currently stationary or mobile. Hence nomadic encompasses work in organisations characterised by project work, where people move from one project to the next, work where people commute or telecommute, as well as work in flexible office settings where users may have a permanent desk, and/or move frequently between working at their desk and working in specially dedicated rooms or on site (See [2]). With the focus on transitions between work situations, collaborating ensembles, computer support and location, the nomadic perspective corresponds well to our use of boundaries, because nomadic working is exactly about lack of stable border between work situation, and about a constant generation of boundaries (between work groups, between locations, small scale and large, and between technology uses).

The initial empirical investigations and observations of C&E have served to establish a common understanding of work situations, work contexts, use of artifacts and work activities in general. This common understanding has been developed in collaboration with the area managers, and serves as groundwork for creating experimental prototypes of mobile devices and evaluating design scenarios. In the project we have undertaken a combination of:

1. Ethnographic Field Studies: we followed the area managers, both "at home" in the office, and "on site" for inspections, project meetings, etc to observe their daily routines. We participated in formal meetings (area managers, engineers group, architects group, energy specialists group).

2. Situated Interviews: We did in-situ informal interviews with area managers on topics arising from conversation and observation.

3. Cultural Probes: Area managers were asked to make a photo diary representing typical scenes from their work.

4. Workshops: Different methods and group activities including synergy maps, future workshops and situation games have supported the analysis and development of prototypes.

5. Prototyping: Exploratory design of prototypes helped prompt a) perspectives for information sharing and building up a departmental common knowledge base, b) ideas for mobile and spatial technologies which support the distribution of information and knowledge, as well as ideas on the interaction between small (handheld) and big (desktop-like) user interfaces.

Observations, interviews and workshops have been recorded on video as documentation and used as basis for analysis. In the communication with area managers we have focused on using still pictures, in particular the photo diary produced by the area managers themselves. The prototypes we present in the following are developed in collaboration with the area managers in the course of the events described above. They help to explore examples of the changes requested by the area managers in relation to their current work practice and have helped us explore the possibilities and constraints of influencing boundary work through recent computer technology.

1.1 Case introduction: The Construction- and Energy Office

C&E deals with maintenance of all of the county's institutions and buildings such as high-schools and hospitals. For a period of ten months we have been following the work of eight area managers who are responsible for four different business areas: children and youth, education and workplace, adult handicapped, and psychiatry. Two area managers are related to each area, typically one architect and one engineer. Their work tasks complement each other: While the architect primarily deals with maintenance of the physical structures, the engineer deals with sub-structures (pipes, plumbing, electrical wiring, etc.) as well as energy consumption.

In recent years, organisational and structural changes have affected employee's working groups and domains very directly seen from the perspective of boundary work. First of all, new role definitions between the area managers and their "customers" have caused both internal and external changes. Internally, the area managers have been pushed to reconsider their own roles and ways of working, which have previously been very self-controlled and autonomous, and thereby they have also increasingly been pushed to compare work routines and habits with those of other area managers. This change has been further strengthened by the stepwise introduction of new information technology for filing and sharing work documentation and material, and we will return to this point in the next section. Externally, new questions have arisen in relation to defining new roles vis-á-vis public institutions, as well as new roles in relation to the county administration as a whole.

Historically, C&E has developed in various ways that are important to our analysis: The Construction department was originally a solitary department located in the main County Administration building. The Energy department was started in the mid 1980's. At the same time, economic responsibility was handed over to the municipal institutions belonging to the county, meaning that institutions were themselves responsible for administering maintenance and repairs of buildings. In addition to that, they became accountable for controlling energy consumption. To C&E this meant a shift from being assigned institutions as a bureaucratic maneuvre from above, to having to offer their services to individual institutions.

By 1990 the two departments Construction and Energy were physically united as one department, officially named the Construction and Energy Consumption Office (C&E). C&E was further given the task of supervising all construction work and energy consumption of a number of public institutions. With these organisational changes, new qualifications and experiences came into play, accelerated by the introduction of new software for supervisory work. By the mid 1990's the material assets of all County buildings were calculated. The estimate resulted in a political decision to give restoration and maintenance high priority in order to preserve these assets. Hence, organisational change happened again. C&E was split into two sections: one for

larger projects mainly concerned with erecting new buildings (C&E Project), and one for maintenance, counselling and energy consumption of existing buildings (C&E Counsel). These changes were carried out through the late 1990's, still keeping the department as one unit with shared management and shared physical location. By the end of the 90's, a more radical change happened as part of the general drive in politics for privatisation of public services: C&E was required to operate in competition with private enterprises, and thereby forced to earn its own money through market competition. Arguments for the organisational changes were primarily:

1. The demand for development and administration of a county-wide construction and energy consumption directive.

2. Changes in economic funding from municipal subsidiaries to market conditions.

The organisational and political changes caused endless debates in everyday work at C&E concerning which projects were more business and which were more public service. Today, C&E Project is 100 % market funded, meaning that no county project is automatically assigned to the department. C&E Counsel has both advisory and supervisory tasks, hence running a combined business of market competition and prearranged public funding.

In conclusion, from the early 1990's and onwards, C&E has seen constant organisational and political changes. Despite these, it is still largely regarded by the customers (the public institutions) as a public service organisation. In reality, C&E has been forced to earn more and more of its own funding, resulting in a new form of customer relation. These changes have affected the employees' general self-understanding and their work role(s), again affecting general relations to the customers as well as the definitions and understandings of the work tasks performed. We witnessed examples of these changes during our project, e.g. C&E was faced with a wave of layoffs in response to a faltering budget within the organisation, which made the employees even more insecure about both their individual role in the organisation and the role of C&E as a whole. Just as the organisation was starting to re-adjust to these new circumstances (which, for C&E Counsel meant losing 40% of their employees!), they discovered that the financial problems were much deeper than expected, leading to the management at C&E being accused in media for financial fraud and bribery. This whole process is furthermore part of a larger political boundary process to redefine the county administration at large, and eventually perhaps get rid of the level of county administration.

With or without the help of these latest developments, fields of tension have been developing within C&E, where the boundaries of internal as well as external working relations and conditions are constantly put into question and re-framed. The remaining part of this paper will focus on examples of these boundaries and their development, and on how the employment of a multitude of IT systems and artifacts either support or contradict the current needs of the organisation.

2. RELATED WORK

In our past work we have studied a public organisation and how it developed historically in the field of tension between the organisational rules regulating it and the technology applied in it. The work domain was that of labour inspection. Markussen [14] described three kinds of roles developed as ways of managing the work, and Bødker [3] discussed how these roles as well as a general view of organisation influenced how technology was developed in the organisation. The original self-conception of inspectors was that of the sheriff relating to the notion of prevention and the therapist relating to an educational practice. With increasing demands from above to account for every move taken by the organisation, and to respond as an organisation in more efficient ways, computer technology was introduced to support reporting and controlling. The bureaucratic perspective was strongly supported in the technology through what Bødker [3] defines as a system perspective. The classical bureaucracy was substituted by a combination of self-governing groups and branches and this increased "upwards" accounting. New technological demands came up, yet they were difficult to honour due to the constraints of the existing technology. In this manner, the technology maintained traces of old ways of working that were no longer attuned to the actual practices of the organisation.

Technologically, the work setting of labour inspection in 1990 and C&E today is very similar: Inspection has to be done on site, but a major part of the accounting for inspections is done back at the office. Preparation primarily needs to be done in the office before a site visit, partly because this is where all files and other relevant information is available. The major difference between the two settings is the potential of providing technological support for on-site work, which was discussed, but never realized in 1990. As for the central database and administration systems at C&E, they have largely been employed in order to ensure reporting, accounting and control, and to meet the bureaucratic rules and regulations of a public service business. The organisation today employs a multitude of IT systems and individual technological artifacts that are largely unconnected, and which support and maintain very different working routines and tasks. As concluded in the labour inspection case, technology in this way support boundaries that are in many ways inappropriate to the current needs of the organisation.

In many anthropological studies, considerable attention has been paid to boundaries. Social anthropologist Mary Douglas [8] pointed out how we, as we construct our institutions, are squeezing each other's ideas into a common shape in order to prove their legitimacy. When an organisation changes due to inner or outer circumstances, the institutional boundaries are also subject to change. If the changes are radical and/or not sufficiently coordinated and guided, the organisation risks loosing the common shape that normally would legitimate the workings of the organisation. Accordingly, such changes cause disturbances and uncertainty to the participants. This may cause misunderstandings and discussions in relations to boundary work and boundary crossings internally as well as externally.

Also Hirschhorn [12] examined the formation and maintenance of organisational boundaries, but from a psychodynamical point of view. He connected organisational boundaries with anxiety and feelings of aggression, and examined how people take and violate roles. He pointed out that do-

mains, roles and boundaries are not given by circumstances: none of us can live without the crutches made up by boundary work, for it is our very selves that are staged enacting them again and anew. In this way, they help us live with the anxieties of change in any job or in life in general. As described through the historical development at C&E, organisational changes affect work domains and tasks, and thereby internal and external roles and relations change, and so do the boundaries marking them. According to Hirschhorn this is likely to cause individual and group-oriented anxieties as a consequence of changes in role definitions.

Dourish & Palen [9] use the socio-psychological theory of Altman to discuss boundary working and technology for such from the perspective of the individual and how he or she on the one hand constructs his boundaries and public appearance in a physical or virtual space, while delimiting himself from this same public. Our perspective shares with theirs the focus on the generative processes that are needed. Our focus is however not on the individual. Nonetheless, we see the redefinition of the work-roles of area managers - from being responsible for a certain domain, to being defined through the competencies that they have - as an example where the ongoing construction of the personal boundaries can become very relevant. As pointed out by Dourish & Palen [9], such boundary creation is based on the ability among area managers to reflexively interpret and anticipate the actions of others, and it has a temporal dimension involving the present as well as the future and the past, in the current case the area managers are easily stuck with the old role of being responsible for a certain domain, if work is not done to shape their new identity as a person with certain competencies.

Fitzpatrick et al. [10] use Strauss' understanding of social worlds, locales and trajectories. They primarily take an already existing social and physical structure for granted and propose technology that is to fit into these in order to

> "facilitate an integrated work environment and seamless transition among different work settings" ([10], p.10).

Accordingly, and contrary to our view, they do not see technology as a means of working boundaries. Our approach deals with technology as both enablers and inhibitors of boundary movement. The analysis of the technology present in an organisation is vital to the understanding of the social and organisational worlds and the boundaries that exist within them. Correspondingly, envisioning future technology is a powerful means of identifying and moving boundaries.

Brown & Duguid's [5] analysis of border working is also important in relation to discussions of boundaries and boundary dynamics. In accordance with [5], a border marks a difference between practice and the meaning of a practice, and this presents a fruitful concept for what to look for in the physical-social environment. Using the book as a paradigm case, [5] showed how a physical space and a cultural space is marked up in centres, peripheries and borders. They point to the essentials of learning with respect to border working. Brown and Duguid in this respect draw on Lave and Wenger's notion of legitimate peripheral participation [13], which points to the importance of participating on the borders in order to become full participants of a group e.g. an institution or an organisation. Many authors have used

thoughts similar to those of Brown & Duguid to describe phenomena of objects, artifacts and documents crossing the boundaries between communities of practice ([15, 16, 4, 6]. The crucial point in Brown and Duguid's analysis is that the borderline is a derivative of a centre and its periphery. However, Brown & Duguid in contrast to Barth [1] do not try to understand the conditions under which a border develops. Rather, they are interested in understanding the conditions under which the

> "border develops into a resource" ([5], p. 18).

Thus the border is taken for granted. What [1] has in mind is neither to focus on the borderline, nor to focus on the boundary. His concern is with boundaries in interaction. Barth's boundaries are not static. Brown and Duguid's borderline is. Barth's boundaries are constantly being recreated, reaffirmed, negotiated, and even discarded by communities. However, Brown & Duguid and Barth meet on the paradigmatic level: both parties intend to look beyond the object in order to engage more closely with the social contexts (of use) and to respond more directly to communities (of practice), and the negotiations their members undertake.

Cohen [7] sees boundary as being constantly in the making, thus supporting Barth's suggestion to look for generative processes. Cohen linked Barth's boundary concept with the notion of community. We apply the boundary notion instead of the borderline notion for the study of communities of practice. By focusing on boundary work rather than border crossing, our work in this paper will focus on processes and situations generating boundaries rather than on boundary objects. In the following we will look further at the conditions under which boundaries develop, in particular we will look at the ways in which computer technology plays a role in these generative processes.

3. BOUNDARY WORK AND TECHNOLOGY EMPLOYMENT AT C&E

C&E area managers hold a huge number of professional contacts, both inside and outside their organisation. The interesting point is that to a large extent they don't share these contacts. The links to associates are based on individual's acquaintance with people in other organisations and institutions. Area managers see these many contacts as an expression of dialogue within C&E. Yet they do not share contacts and admit that

> "each of us is an anarchist. We work on our own, and everybody does it his/her own way."

Given this acknowledged anarchy, combined with the previously mentioned turbulent organisational and political environment and the ongoing change of role definition, it is interesting what holds the organisation together? This led us to identify three generative processes of boundary work that are touching on these three issues: between the organisation and its customers; between competencies within the organisation; and between the various physical locations of work (particularly relating to the transitions between work in the office and work on site). These are discussed in detail in the following.

3.1 Boundary work 1:

The work to maintain and develop the boundary between the organisation and its customers.

As described above, the changing organisational and budget conditions have caused tensions and changes to the work of the area managers. First of all, the individual workers are confused about their role in relation to the institutional contacts. They used to see themselves as counsellors or advisors who helped and supported the institutional management in getting the most out of the money provided by the county. By and large, they where, themselves, in charge of the level of service provided, and how they spent the time given for each institution. With the new organisation, the area managers have to "earn their own money", as they express it. This has caused work tasks to be questioned, and the formation of new and sharper borders between services to be paid for separately by customers. Henry's case illustrates this dilemma:

> "At an institution for adult handicapped people the caretaker, John, is concerned about a potential problem with the heating system. My job is to advise him on how to deal with the energy conservation issues. However, I am not to solve his problem, rather we are supposed to get caretakers solving their problems themselves. I am just a consultant. The question is 'What can he do in order to reduce expenses for heating?' It is not my job to call the plumber. On the other hand, if John asks me to call, I regard this as a new work task. John has reasons not to call the plumber. He feels insecure about the task. It might not be settled with just a single call. So I do it in order to get the job started."

Before the organisational changes, the area managers took responsibility for a range of small coordination jobs for the institutions without ever really defining them as 'work' - these jobs were only minor disturbances in the larger scope of things and the area managers never had to specify their time down to that level of detail. Now, however, they are forced to specify almost every minute of the time they spend with their customers for billing purposes, and what used to be a friendly gesture is now an object of discussion in relation to the cost of their services for institutions they know run on a strict budget. The area managers feel stuck between not making enough money for themselves and risking to alienate their customers who have been used to take these types of services for granted. Henry elaborates:

> "We are talking about a state of ambivalent affairs, one that refers back to former times and how things were handled then. It's a catch. If it were my own private enterprise I would send a bill. But what shall I do? To a certain extend it is also our job to counsel. A tiny part of our funding is dedicated to counselling. And the customer knows it. So it's always a question of when the line is crossed. But, yeah, I know, we should be better at teaching our customers to pay for our services."

Henry's dilemma has an even wider context, namely that of a public service institution in competition with private businesses. C&E needs to compete, yet it has to live under strict rules e.g. of what public organisations can register about private citizens and companies due to public regulations. For example this means that C&E is not allowed to maintain a list of good/bad performance of entrepreneurs. In this way, in opposition to private companies, political directives limit the possibilities for systematic information gathering and exchange of information internally at C&E. This context is well understood by C&E officers, and the situation is perceived as a paradox.

Another example further illustrates how IT enters the picture: Rudy, an architect visiting a school for handicapped children, faces a request from a customer about on-line access to C&E databases: Peter, a secondary school headmaster asks for an alternative to the current two-portfolio system where two copies of all documents are kept, one at the institution and one in C&E. Peter wants on-line access to the C&E database. Rudy:

> "Right, I understand the request. Recently, there has been some debate about allowing on-line access for bigger institutions like hospitals. But they won't be allowed to make on-line changes. It's read-only."

Rudy continues to explain how database and folders are linked, and why Peter, as a customer, always gets updates for the portfolio. This example illustrates that we are far from the political ideal of a digital authority or e-governance, as formulated by Danish government officials at the turn of the millennium. In this sense Rudy and his colleagues carry the burden of the past, and struggle making demands for adjustments meaningful in daily practice. Although Peter is a treated as a customer of the county, his school pays C&E regularly throughout the year. At the same time, Peter can make his own decisions on what and when he spends his budget. Rudy is a mediator, a counsellor and an inspector, all in one. The borders between these roles exist, but they are erratic, fluctuating between former practice and future visions of practice.

During a future workshop with the area managers, we discussed and developed the concept for a technical solution to some of these problems, namely defining billable work tasks both to themselves and to their customers. The idea is: if the individual institutions had access to online key information e.g. about their buildings, energy consumption and maintenance plans, they would be much better equipped to deal with the day-to-day problems. An online overview of the energy consumption, updated continuously, would allow the local janitors or technical staff to make their own strategies for saving money on the energy bill. Similarly, an online overview of the most recent architectural drawings of the building would enable the local administration to be more involved in the process of re-building or repairing the facilities. This information is already present in C&E's databases and would only require setting up a client at the institution and granting them access to the databases. At the workshop we went on to sketch a software solution with overlays to the original CAD-drawings that would enable the institutions to make suggestions for alterations to the buildings and send these to the C&E office, who would then be in charge of evaluating and accepting or rejecting these suggestions. The philosophy is, that if the institution gets more information to base decisions on, they will be much better

equipped to make the kind of low-scale repair and maintenance decisions they are currently relying on C&E to make for them. Furthermore, it would give the area managers valuable feedback on how the institutions envision the ongoing maintenance and development of their facilities which may even serve as a foundation for future projects between C&E and the institutions, strengthening their mutual relationship.

3.2 Boundary work 2:

The work to maintain and develop the boundaries between competencies within the organisation

We now move on to look at how the organisational changes have moved boundaries. Both with respect to the workers' understanding of their work and competencies in relation to their co-workers, and the effects their current and future work practise has on the use of technology. We divide this boundary into two sections in accordance with this: a practice-related and a technology-related competency boundary.

3.2.1 The practice-related competency boundary

As described in the case introduction, the area managers work in pairs, each pair being responsible for one of four business areas: children and youth, education and workplace, adult handicapped and psychiatry. Following the organisational changes, management has focused on/demanded a more group-oriented way of organising work, where people cooperate based on relevant competencies not necessarily based on their profession (architect or engineer). This new way of envisioning work has introduced some level of tension between the professions and has led the individual employee to consider his or her qualifications within C&E. In general and practical terms, the architects form one group, and the engineers make up another, and in many ways these two groups complement each other in terms of areas of responsibility and they, to a large extend, maintain boundaries between the work tasks they are responsible for.

An example: Once a year Rudy, the architect, visits Peter's school to check building defects and gives advice to Peter on necessary repairs. Their discussion is mainly about preferences of repairs granted by budgetary limitations and construction requirements. After sorting out budget matters, Peter and Rudy take a tour of all buildings. When passing by a rotten window frame Rudy dismisses Peters claim.

> "It's not that a repair is too expensive. It's just that it is not my business. This is an engineer's concern."

To the area managers, these boundaries between the professions are sound because they help them define their areas of responsibility both in relation to their customers and in relation to each other. This, however, does not imply that they do not work together or that an engineer knows nothing about the work tasks of an architect - on the contrary. They collect work tasks for each other when they go on inspection visits, and use that information to keep each other updated on the work load in their area.

The wish for a new group-oriented organisation, and the abandoning of the traditional pairs and business areas have pushed the two groups of employees into a situation where they are uncertain of their own qualifications and place in the organisation, actually causing the split between professions to be more visible than it apparently used to be. Debates about scopes of duties become vital as the area managers are confronted with a need to share projects, knowledge and responsibility. One such debate involved the use of CARETAKER system. CARETAKER is a central software application used for basic registration of data shared by both architects and engineers. An architect starts the registration of any new institution, by creating a file including all data for buildings, AutoCAD drawings and pictures taken. The engineer supplies data on energy consumption and other engineering tasks. Later, budget figures and statistics are added.

However, CARETAKER is not used pro-actively by the architects. One explanation lies in differences relating to professions as well differences in work tasks and data. Engineering data are much more dynamic than construction data: figures for energy consumption run in via the FA6 application, a system which continuously collects sensory information from the different institutions concerning their energy consumption, thus producing statistics and graphics for every week, every month, and every year. Architects use CARETAKER mainly for reference use. Asked why the architects have not used CARETAKER one of them replied:

> "because that's simply not the way architects think. But yes, CARETAKER could be a resource architects could use well."

Though this seems to be a concern primarily caused by differences in work practices, there are other concerns that explain why CARETAKER is not used equally much by everybody: CARETAKER is a complex system that only runs on some of the desktop computers at the C&E office. Consequently, some of the area managers have to borrow PC's from their colleagues to use CARETAKER that requires some training to use. Hence, CARETAKER is seen as potentially useful but in practice often regarded a waste of both the time of the user and of the colleague from whom the computer must be borrowed. A very intermediate compromise is currently made by asking the architect with the most experience in using the system to enter large parts the relevant registration information.

We addressed this specific problem at a design workshop and came up with a prototype solution to how CARETAKER could become a tool for everybody by linking the information to the drawings kept in the AutoCAD systems. Engineers could use the CARETAKER application as their primary entrance point while architects could annotate CAD-drawings with information to be transferred automatically into the CARETAKER system. The shared view should be produced by a "room-generator" that relates all information (both architect-related and engineer-related information - from the material the walls are made of to the overview of energy consumption for the room) to the corresponding drawing of the physical location. Furthermore, this could be linked with the function described in 3.1 that enables customers to add sketches of minor architectural changes on the AutoCAD drawings themselves via e.g. a web interface.

This example shows how crossing the competency boundary in a workshop could help envision a future where information technology supports cooperative work. Grønbæk et. al. [11] offers an interesting solution to how different mate-

rials, digital as well as physical may be linked to produce a shared view into very heterogeneous types of material.

There is a need for moving from the specific work-arounds that may work for the individual, to solutions that support both the individual employee and C&E as a knowledge-based organisation. Using a shared calendar system and creating systems that can combine 'engineer-related' and 'architect-related' information into a shared repository/view, as described above, are small steps in that direction. However, to be able to change the old boundary between engineers and architects requires support for forming a new understanding of the qualifications within the organisation, and thus the building of new boundaries. At C&E, one recent organisational approach to this more fundamental boundary change is asking each employee to make a contribution to a 'who's who'. This is a process where each employee become aware of their own specific competencies, and have a possibility of making these visible within the organisation.

3.2.2   *The technology-related compentency boundary*

A related competency boundary now becomes visible: a boundary dealing with individual use of tools and technology. As described earlier, the area managers have quite different work habits based on individual and professional experience and choice. The obvious advantage in allowing a range of different tools rather than enforcing a 'one tool for one task' dogma is that it supports individuality and flexibility. This builds on the understanding that different people often prefer different tools for solving similar tasks. The disadvantage, however, is the problem of fragmentation and isolation of information, especially when the different tools are poorly integrated and sharing or transfer of information is difficult. The result is the absence of a shared view (other than the paper-based institution portfolio) into all the information.

As an example illustrating this problem, coordination between area managers suffer because they currently use four different calendar systems in the organisation: a paper-based reception calendar used primarily by secretaries for answering and redirecting telephone calls; a shared electronic calendar system, GroupWise, which provides users with views into their colleague's calendars; an electronic key that registers coming and leaving the building; and, finally, everybody's individual paper diaries. The registrations made in GroupWise and through the electronic keys are accessible from all PCs in the building. These four types of calendars all have pros and cons - e.g. the individual paper diaries are helpful for the individual planning, independent of location, but poor for locating people or planning group activities, etc. The balance between sharing relevant information and allowing individuals to use their preferred tools is tricky at best and difficult to enforce. C&E is currently trying to strike this balance by making it mandatory for all employees to use GroupWise as the one, shared calendar system and letting the other systems work as supplements for the individual employee. Not surprisingly, this is met with reluctance, particularly by the people who are unfamiliar with GroupWise, but it is a necessary step to support the overall boundary (maintaining and developing the boundaries between competencies within the organisation).

Another example of this boundary is that some of the software systems, which are used by all area managers, have been deemed unfit to suit specific parts of the work tasks, and have been substituted with other software programs. E.g. C&E currently use and maintain at least three different database systems. A major trade-off is the poor integration between the systems, which forces the area managers to undertake double- and sometimes triple-bookkeeping or to invent ad hoc solutions, as the following example describes: Simon, an engineer who supervises energy consumption, deals with two systems processing data for electricity, water, and heating controls:

1. FA 6 is a system that dials up via modem to institutions and calls in data every day; the system displays an endless list of numbers.

2. CC-Consumption Control is a system transforming data from FA 6 into graphic displays, allowing Simon to compare data by day, week, month or year; thus deviations become visible, and Simon can make a call or plan a visit on site.

Unfortunately the two systems are not integrated. FA 6 runs on a Windows 95 platform, CC runs on Windows NT. For reasons of copyright and use of different software developers it has not been possible to merge the two systems or to enable communication between them. Simon has found a way around these hindrances by making his own software-hacks to get the FA 6 information into CC, yet his solution does not work for the rest of the organisation.

The main disadvantage is that the fragmented and disconnected technology use in no way supports the creation of shared work understandings and work habits, that otherwise could support the creation of a better internal group identity and a common work task understanding. This makes a knowledge-based organisation of work difficult to implement, and further promotes the boundary problems concerning the creation of new boundary relations to the customers, as described in 3.1.

The main issue to be addressed with respect to this boundary is a higher degree of integration between the different, and necessary, applications used. If tools were more strongly integrated, and people were able to share or transfer information more easily, these disadvantages would be eliminated or at least diminished. However, we take the need for flexibility in tool usage very seriously and give an example of how to support this through the prototype described in 3.3.

3.3   **Boundary work 3:**

The work to maintain and develop boundaries between various physical locations of work, in particular between what is done in the office and what is done on site.

Being an area manager in C&E Counsel consists, as described in 1.1, primarily of project management, inspection work and institution counselling. Area managers often act as coordinators and managers of projects running over several months and deal with finding contractors for specific jobs and generally keeping an overview of the maintenance, repair and rebuilding tasks involved.

Other aspects of the area mangers' work are the regular inspection visits and the implementation of strategies for energy conservation. Consequently, their work time is divided between coordinating/planning work at the office and going out on site to various types of meetings and inspection

work. To support the work at the office, the area managers use a range of IT systems to manage projects and maintain an overview of the status of the individual institutions along with each institution's paper portfolio. In addition to the already mentioned (CARETAKER, CC, FA 6, Groupwise), these include the BSA system for project management in building projects. BSA contains features for breaking projects into tasks and assigning e.g. cost, time, contractor, and coordinator and time registration used for billing.

In general, area managers' work can be characterised as highly mobile and non-routine with a corresponding high degree of flexibility needed to be able to respond to changes in plans as they occur. This is because ad hoc meetings on site with carpenters, bricklayers, roofers and other contractors as well as janitors and institution managers are often needed to keep a project on track and coordinate the different efforts. Regular inspection visits, on the other hand, offer more time to plan and prepare from the office as do a number of the scheduled meetings during a project that serve the general purpose of keeping the project on track. During these meetings it is always necessary to refer to shared material such as blueprints, architect drawings, time-lines, contractor bids, most of which belong in the project portfolio. For energy consumption inspections, the area manager usually brings print-outs of the institutions' energy consumption during the past weeks and other relevant data from CC. Common to the shared materials is that none of them are available electronically on site.

Not surprisingly, a great deal of effort goes into 'checking information out' of the various computer applications and other information repositories at the office in preparation for meetings and 'checking information into' the computer applications and institution and project portfolios upon the area managers' return from site. We will try to illustrate with a general example of work from our field study:

Architects and engineers usually bring a digital camera when they visit a local institution for a building inspection. Pictures are taken of relevant details, and handwritten paper annotations are made with reference to the specific pictures. Notes and pictures are related to the physical locations through a standardised naming and numbering scheme, as well as by references to known features of the environment or the official maps of the buildings. Notes are generally written on site as the pictures are taken, in order to remember details and keep track of relevant information, so that the inspection can be reconstructed upon arrival at the office. When they return home (or often more likely a day or two later), the pictures are downloaded and stored, the notes are typed into a project management tool as well as CARETAKER, and the data is again associated; appropriate picture(s) with relevant text.

This 'juggling' and perpetual updating and rewriting of information is a constant source of frustration to the area managers who, rightly, perceive these technical problems of integration between software systems to be a hindrance to their real object of work: inspections, counselling and project management. At the future workshop, we discussed the example concerning photo registration and proposed different solutions for entering data into the different applications more easily, e.g. using a Dictaphone and make audio notes to photos as an alternative to the notes on paper, and being able to associate the audio clip with its corresponding picture. The area managers were very enthusiastic about

this idea, but they agreed that using audio would only be a viable solution if an automatic translation from audio to text was available; if they were forced to transcribe all audio notes themselves, they preferred the current paper system.

The area managers move through very different work settings characterised not only by the physical location, but also by the difference in the character of the work tasks, the individual carrying out the task, and the resources, people and tools at hand (computerised and otherwise). Consequently, the resources currently carried on site visits, vary greatly, depending on the general nature of the task and the work routines of the individual; laptop computers, printouts of the institution's monthly energy consumption, architect drawings and blueprints, digital cameras, pen and paper, calendar, mobile phones etc. Some area managers use the passenger seat in the front of their car as a 'mobile office', storing all their papers and technology next to them and some even (try to) work in the car if pauses between visits at customers occur.

Most of the prototypes discussed to support the nomadic aspects of the area managers' work simply deal with a much higher degree of technical integration between the existing systems employed. However, access to key information on site, on-line updating of information and access to information from heterogeneous devices are also important aspects in supporting the mobility and flexibility necessary in their work. Accordingly, we focus on design aspects and functionality aspects of integration as well as integration on a technical level.

During the project we have worked on developing a set of prototypes based on three different types of technology (tablet PC, PDA and mobile phone (multimedia phone)), enabling the area managers to access information from their office systems on site as well as location-related information, to record information during inspections and project meetings, and which offers easy update possibilities back into the systems at the office. An interesting addition to this prototype, particularly for the inspection visits where the area managers use forms extensively, is the introduction of the Anoto pen which would provide a direct link between the forms and the corresponding database. The users rejected the idea of using a digital pen when first presented but were interested in seeing a concrete implementation of a form to be able to assess the technology properly.

Unfortunately, the project was closed down before we had a chance to implement any of the prototypes satisfactorily, due to the growing organisational and financial problems in the user organisation mentioned in 1.1

4. CONCLUSIONS

The boundaries of work at C&E are under redefinition at at least three different levels.

First, the boundaries are moving with respect to their relation to customers. Earlier, the personal, advisory relationship with the customer was essential, but with recent changes in budgeting and legislation, buying and selling services has become a main issue. Current technology is primarily suited to support the personal relationship, because it is used at C&E by the area managers and only brought to the customer when meeting him (and even then only to some extend). This technology becomes legacy technology that is preventive of the new boundary with customers. As an answer to this, the area managers have formulated a

wish for technologies that would allow a higher degree of sharing between C&E and their customers and, hopefully, help them fend off the small requests that they find it difficult to charge customers for today. Hence, the technology will at the same time support increased cooperation with customers by providing more updated information, and by allowing customers to change this information, and it will help create new boundaries by making the roles of buyers and sellers more visible.

Second, boundaries are moving within the organisation, away from the paired areas of responsibility, and more interesting to our analysis, boundaries seem to be established around several of the computer systems applied, established in parts due to the anarchic way technology gets introduced and used in the organisation, and in parts because the area managers do not have equal access to all systems. This means that some systems which could have supported the cooperation between architects and engineers, in some instances have been claimed as tools for one group, at the cost of the needs and wishes of the other.

Third, the frequent location shifts result in temporary and largely unforeseeable constellations of people, technology and input/output available from situation to situation. At this level it is, accordingly, a constant process for the area managers to renegotiate boundaries and to move between settings. The current separation between the office as a location where one is trying to foresee the situation and information needs, and the site visit where situations and information needs evolve despite what the area manager might have foreseen, creates a need for technologies that support working these boundaries.

In this paper we have looked at computer technology and the way it is supporting or prohibiting boundary work. With changing boundaries new needs occur and technology needs changing accordingly. We have seen how boundaries between the organisation and its customers lead to new needs for sharing of information and computer applications. Within the organisation, boundaries between competencies and areas of responsibility are equally influential of the need for information sharing and computer support. Finally, we have seen how moving between locations implies a type of boundary work where different locations imply different needs, yet some level of integration is desired. In other words, boundary work provides a perspective on integration versus separation of computer applications and information access. With our analysis we opt for means of supporting boundaries when these are productive and for changing boundaries when this seems more appropriate, instead of equal information access independent of organisational location, work activity or location. Similarly our analysis points against homogeneous systems to be used by everybody. We propose instead to focus on the flexible and integrated use of different tools depending on time-place-individual choice etc. This means, that design and implementation of new technologies has to focus on the dynamic development of the use situation as a dynamic constitution of relations between tasks, places and present technologies and respect the individual's work practice.

Compared with other studies focusing on borders or boundaries this perspective is more dynamic in that it does not take borders for granted and work to design technology to support these. Neither does it primarily focus on boundary crossing capacities which is an additional perspective that could be applied to e.g. the technologies supporting information exchange between area managers and janitors, though still primarily taking the bounda-ries for granted.

5. ACKNOWLEDGEMENTS

6. REFERENCES

[1] F. Barth. *Ethnic Groups and Boundaries*. Boston: Little, Brown, 1969.

[2] E. Bjerrum and S. Bødker. Learning and living in the 'new office'. In *Proceedings of the 8th European Conference on Computer Supported Cooperative Work.*, 2003. To be published.

[3] S. Bødker. Historical analysis and conflicting perspectives - contextualizing hci. In J. G. L. Bass and C. Unger, editors, *Human-Computer interaction. 3rd International Conference, EWHCI '93*, volume 753 of *Springer Lecture Notes in Computer Science*, pages 1–10, 1993.

[4] S. Bødker. Understanding representation in design. *Human-Computer Interaction*, 13(2):107–125, 1998.

[5] J. Brown and P. Duguid. Borderline issues: Social and material aspects of design. *Human-Computer Interaction.*, 9:3–36, 1994. Lawrence Erlbaum Associates, Inc.

[6] M. Büscher, S. Gill, P. Mogensen, and D. Shapiro. Landscapes of practice. *Computer Supported Cooperative Work: The Journal of Collaborative Computing*, 10(1):1–28, 2001.

[7] A. Cohen. *The Symbolic Construction of Community (Key Ideas)*. London: Tavistock, 1989.

[8] M. Douglas. *How Institutions Think*. Syracuse University Press, 1986.

[9] P. Dourish and L. Palen. Unpacking "privacy" for a networked world. In V. Bellotti, T. Erickson, G. Cockton, and P. Korhonen, editors, *Proceedings of the 2003 ACM Conference on Human Factors in Computing Systems (CHI'03)*, pages 129–136. ACM, 2003.

[10] G. Fitzpatrick. *The Locales Framework: Understanding and Designing for Wicked Problems*. The Klüwer International Series on Computer Supported Cooperative Work, V. 1. Klüwer Academic Publishers, 2003.

[11] K. Grønbæk, J. F. Kristensen, M. A. Eriksen, and P. Ørbæk. Physical hypermedia: Organizing collections of mixed physical and digital material. In *Proceedings of the 2003 ACM Hypertext Conference*, 2003. To be published.

[12] L. Hirschhorn. *The Workplace Within. Psychodynamics of Organizational Life*. Cambridge, Mass.: The MIT Press, 1999.

[13] J. Lave and E. Wenger. *Situated Learning: Legitemate peripheral participation*. Cambridge University Press., Cambridge, UK, 1991.

[14] R. Markussen. A historical perspective on work practices and technology. In P. B. Andersen,

B. Holmqvist, and J. F. Jensen, editors, *The Computer as a Medium*, pages 457–476. Cambridge University Press, 1994.

[15] L. Star. *Distributed Artificial Intelligence*, volume II, chapter 3. The structure of Ill-Structured Solutions: Boundary Objects and Heterogeneous Distributed Problem solving., pages 37–54. Morgan Kaufmann, 1989.

[16] L. Star and J. R. Griesemer. Institutional ecology, 'translations' and boundary objects: Amateurs and professionals in Berkeley's museum of vertebrate zoology. *Social Studies of Science*, 19:387–420, 1989.