SPACES WITHIN SPACES
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Spaces within Spaces

The Construction of a Collaborative Reality

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Not only do *people make spaces*, but also *spaces make people.*
Bethan Benwell and Elizabeth Stokoe (2006: 211)
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Hillevi Sundholm
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This thesis is about collaboration in interactive spaces. Collaboration is an important part of human activity, whether professional or everyday. People have various reasons for collaborating, but they do engage in cooperative efforts, communicating and interacting with each other. Being cooperative, however, is not possible all the time; we all alternate between the need to be with others and to work alone. Interactive spaces are technology-enhanced environments that have large, shared displays in combination with private displays and software tools that facilitate fluent sharing of information between the people and the resources; team members can collaborate physically in such a space or at a distance. One of the main ideas behind such environments is that the actors should experience their work as interaction with a combination of tools and not with single objects.

To be more specific: a large touch-sensitive display on a wall in an interactive space allows users to interact with it in several ways. They can write directly on the display using special pencils or their fingers, or they can use the ordinary mouse and keyboard, or they can send information from another computer using a software tool that supports fluent sharing between the available computers in the space. They could also use the electronic whiteboard on the wall display to make sketches and brainstorm ideas. At first glance it seems much like an ordinary whiteboard except that the text pieces and drawings are rougher, but in fact the digital feature lets the users treat data and create documents differently: they can save, re-access, change, and move them, and when connected to the Internet they can also search for information in parallel. The access to the Internet makes it also possible to mix inserted pictures found on the web with sketches made by hand. Furthermore, a large display, as contrasted to a desktop for a single user, makes it possible for all participants to have an appropriate view of the shared documents, which could otherwise be a problem (Mark et al. 2002). This in turn may allow more people to have an impact on the overall work.

In an interactive space with many computers, either shared or private, the problem is how to move data easily from one computer to another. This is why users appreciate the specific software tools; the tools also give the actors the feeling that they are interacting with a combination of tools and not individual ones.
Aim of the thesis and research issues

The aim of this thesis is to understand collaborative activities in interactive spaces in terms of how team members are allowed to contribute to the overall work and what influence the physical qualities of space have on the collaboration. The way collaborative activities unfold is influenced by several factors: the composition of the team, the team’s objectives as well as the team members’ personal objectives, the tools they have at their disposal, where they collaborate, etc. However, the most basic assumption is that the members of a team share at least one goal and that they need to coordinate their activities to achieve that shared goal. Tools play an important role in any human action or, as Wertsch (1998: 73) states, “human action is fundamentally shaped by cultural tools”. In the context of collaboration this means that teams interact not only with each other, but also with the physical resources, such as tools and the environment. Therefore it is not possible to separate the collaborative activities from the physical space where the action takes place.

To approach the problem of understanding collaborative activities in interactive spaces three research issues have been considered in this thesis. The first issue is: In what ways are team members allowed to contribute to the overall teamwork? A team’s progress on the task to reach the goal is closely related to the team members’ contributions, which they can make on different levels. They may take a turn in an ongoing discussion, come up with an idea, share an opinion, take the initiative to introduce a new topic, etc. The nature of the contributions depends partly on the individual team members, and partly on their common effort as a team and the material resources available.

The second issue is to some extent related to the first one: How do the team members handle roles and functions in the collaboration? In any teamwork, the team members inevitably have different functions and take on different roles, and often it is important to make good use of the members’ different competences. But team members do not always want, or ask for, their roles; they may also result from some kind of imbalance within the team. Whether or not the members desire their roles or functions, what is important in this work is that they feel they can take on a role they feel good about and that they can contribute to the overall work in the way they want. The distribution of roles depends not only on the individuals on the team, but also on the material resources (Baker 2002).

A third research issue arose during the analyses of the studies: How do the physical qualities of the interactive space impact the collaborative activities? The data analysis revealed that the physical qualities of space—the architecture, the layout of space, the tools, the material qualities of the tools, etc.—seemed to play an important role in how the team members come to
contribute and how they distributed their roles and functions among themselves.

In Chapter 3 the research issues are discussed further, along with the research questions that were derived from them.

**Empirical studies**

For the purpose of this thesis two studies, both focusing on collaborative activities in interactive spaces, were conducted. The settings of the two studies were similar but the activities differed. The first study, conducted in March 2003 in the Department of Computer and Systems Sciences, focused on two student groups that carried out conceptual design activities (brainstorming, searching for information, sketching and making storyboards) over a two-week period. The second study focused on a series of geographically distributed meetings of an international research network. The teams did not work on a common project, but every month they held a meeting at distance, to exchange ideas and knowledge between the labs. The study was carried out from April through December of 2004 at Laboratoire de Design Cognitif (LDC) at Electricité de France (EDF) R&D in Clamart, France. In each of the studies nine two-hour sessions were followed.

Most of the data was collected using video recordings, observations and questionnaires. The analyses, which are influenced by ethnomethodology, are primarily based on detailed investigations of video recordings. Three tools were used in the analyses to various extents: conversation analysis, interaction analysis and initiative-response analysis.

The results and analyses of the empirical studies are presented in Papers I through V, which are appended to the thesis. Papers I and II present the results and analysis from the first study on co-located collaboration, and Papers III and IV present the results from the second study on geographically distributed work. Paper V is based on the results presented in the first four papers and draws more general conclusions regarding issues of space for collaboration in interactive spaces.

**Contributions**

This work focuses on collaborative activities in interactive spaces. The results from this work contribute to the fields of Human-Computer Interaction (HCI), Computer-Supported Cooperative Work (CSCW), and Computer-

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1 Papers I, III and IV are appended in the pdf format in which they were sent to the editors, Paper II was downloaded from the Webproceedings, and Paper V is in the format in which it was submitted. No page numbers have been inserted.
Supported Cooperative Learning (CSCL). The core of its contributions is concrete observations that are based on detailed investigations of video recordings of teams collaborating in interactive spaces. The conclusions drawn from these observations regard three phenomena: the ways that collaborating team members come to contribute to the overall work, the roles the team members take on, and the ways the physical space influences these two processes. This work also contributes through its reflection on methodology regarding the in-depth video analysis.

Outline of the thesis

**Chapter 2** presents the theoretical framework on which this work is based. Its two key concerns are collaboration and space. The former focuses on several characteristics that are particularly relevant in this work, and the latter on various aspects of space that are relevant for understanding collaboration. A general description of interactive spaces is also given.

**Chapter 3** describes the two settings in which the studies were conducted, that is, the setup and the tools of the interactive spaces. It also presents the research questions that are derived from the three research issues presented above.

**Chapter 4** presents the method and the methodological concerns. It focuses on both the methods used and the practical concerns in analyzing the data.

**Chapter 5** provides a brief summary of each paper included in this thesis; the empirical data is also described.

**Chapter 6** concludes the thesis with a discussion of the research conducted and the conclusions drawn, as well as reflections on methodology. It ends with suggestions for future work.
This chapter presents the framework for this thesis, which is divided into three parts. The first part looks closely at collaboration: what collaboration is and what elements characterize it. To better understand the teams’ collaborative activities one must consider where the collaboration takes place. The spatial aspects of the environment affect how the collaboration unfolds. How the teams come to collaborate is not simply a question of the layout of the space and the physical resources available: the experience as well as the material qualities of the physical space also influence the way we interact. The second part examines the concept of ‘space’. Finally, the third part provides an overview of what interactive spaces are: the ideas behind them and what differentiates them from other kinds of workspaces.

Collaboration

In the broadest definition collaboration occurs when more than two persons are working on the same task. However, it can be helpful to define collaboration more precisely. Roschelle and Teasley (1995) define collaboration as a

coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem.

Roschelle and Teasley (1995) also clarify the difference between cooperation and collaboration:

Cooperative work is accomplished by the division of labor among participants, as an activity where each person is responsible for a portion of the problem solving. We focus on collaboration as the mutual engagement of participants in a coordinated effort to solve the problem together.

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2 The concept of ‘joint actions’ (Clark 1996: 59) has an even broader meaning than collaboration; it is defined as “the coordination of individual actions by two or more people”. Compared to collaboration, the concept of joint actions refers to any interaction and need not include a shared goal.
The focus in this thesis is on collaboration, but not only on tasks that concern problem-solving in a strict sense; rather, it is a question of having one or more shared goals towards which the team members are striving. These goals can be more or less clear and well-formulated.

Dillenbourg et al. (1996) point out that collaboration cannot be defined simply as the non-distribution of labor: the distribution of roles between team members is dependent on the task, and may change regularly. However, the distribution of roles depends on more than just the task; the tools used are also part of the team members’ role assignments. For example, Miyake (1986: 174) has found in two-person interaction with a sewing-machine that

The person who has more to say about the current topic takes the task-doer’s role, while the other becomes an observer, monitoring the situation. The observer can contribute by criticizing and giving topic-divergent motions, which are not the primary roles of the task-doer.

Similarly, in a study where children worked on a task in pairs in front of a computer, the child controlling the mouse tended to become the ‘executor’, while the other child was the reflective one, whether acting as a commentator, navigator or strategist (Blaye et al. 1991). When the executor handed over the mouse to the other child, the roles swapped as well. The same phenomenon is found in pair-programming where one talks about ‘driver’ and ‘navigator’ (Bryant et al. 2006). Moreover, Baker (2002) has shown how material resources are part of the process of distributing the roles between actors; in his study students learning physics took part in a computer-mediated problem-solving activity. Further, Rogers and Lindley (2004) conducted a study where they compared teamwork around vertical and horizontal displays; they found that the team members’ roles shifted more often when they were collaborating around a horizontal display. Those teams also explored more ideas and were more aware of their fellow team members’ activities, compared to those collaborating around vertical displays.

Collaboration can take place in the face-to-face (co-located) or at a physical distance (geographically distributed). The principal differences between the two situations are that face-to-face interaction is rich in contextual information, which is limited in the distributed setting, and that the geographically distributed collaboration is dependent on the use of one or more tools. But in any collaborative activity, co-located or not, sharing is an important element: collaboration is about sharing goals, sharing a vision of what must be done to reach the common goals, sharing knowledge, sharing

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3 Roschelle and Teasley (1995) specify the ‘joint problem space’, which is the shared knowledge structure of a problem, as having shared goals and descriptions of the current problem state, and being aware of which problem-solving actions are available and which associations relate those three aspects.
information, sharing understanding, etc. The tools, including ‘social tools’ such as conventions, are instruments for handling and improving the way the collaboration can be carried out: tools need to be appropriated and conventions may need to be created if the already existing ones are not sufficient. Depending on the nature of the task for the team, finding, exploring and developing ideas may be ingredients in the teamwork needed to reach shared goals, especially if the task has a creative character. The rest of this section is devoted to these issues.

Social conventions for collaboration

All actions are situated and all communication is embedded in both the present and the past. To understand what the current situation means we make use of our previous experiences and existing knowledge. In the same way that we try to understand a situation so we can act in the most appropriate way, we have to learn which verbal and nonverbal behaviors are appropriate in which situation (Erickson & Schultz 1997).

People use strategies or techniques to coordinate shared activities and interaction with others; these so-called ‘coordination mechanisms’ (Schmidt & Simone 1996) reduce the amount of articulation collaborators need to coordinate their activities (Simone et al. 1995).

The setting to which we are best adapted is the one that takes place face-to-face; Clark (1996) calls this the ‘principal setting’. All other settings (telephone, videoconferencing, online chatting, etc.) are ‘derivatives’ of face-to-face (Berger & Luckmann 1966). Therefore to handle those ‘derivatives’ we need management techniques and practices; two examples are making explicit agreements and using conventions (Clark 1996). The conventions are normative and guide people towards the correct and acceptable behavior, as well as predicting group behavior (Mark 2002). Within a community members share conventions, which help them to coordinate action and avoid problems (Lewis 1969), and those conventions make the social system stable, efficient, and coherent (Becker and Mark 1998). An example of a convention in western culture is that we greet one another with our right hands when we first meet. Conventions are arbitrary in the sense that they usually result from historical coincidences (Lewis 1969; Clark 1996). For example, we greet with the right hand and not the left (Clark 1996).

Whereas Clark (1996) makes the distinction between explicit agreements and conventions, Becker and Mark (1998) differentiate between explicit and implicit social conventions. The explicit conventions are agreed upon, while the implicit ones are embedded in social practice. When newcomers join a group or community they must become aware of the implicit social conventions (Becker & Mark 1998).

Schön (1983) sees norms as similar to social conventions; both are contracts of shared rules between actors that govern their behavior. Norms con-
sist of both formal and informal understandings about what people can ex-
pect from each other. These reciprocal expectations are often important in
practice. In system design, for instance, the user and designer must share
their expectations about the kinds of communications the system needs to
handle in various kinds of situations (Suchman 1987).

Sharing in collaboration

A shared view of the collective work is fundamental for coordinating activi-
ties. What Dourish and Bellotti (1992) refer to as ‘awareness’ is in this work
referred to as a shared view. They define it as an “understanding of the ac-
tivities of others”, which in turn provides a “context for your own activity”
(Dourish and Bellotti 1992: 107).

An important part of all collaborative work is to maintain both a shared
view and a shared understanding at least to some degree, so that the team
members can perform the work and reach common goals. Collaborating
teams continuously face the task of determining and representing the rele-
vant information so they can have a shared vision of the work situation
(Krauss & Fussell 1990). In long-term collaboration team members have to
establish and maintain awareness of one another’s actions, plans, goals and
activities; this requires them to coordinate their activities (Neale et al. 2004).

Demonstrating an activity to other team members is an efficient mecha-
nism for establishing a shared understanding within the group (Gergle et al.
2002). The visual information that one team member presents to the others
“provides a situational awareness that may change both the structure (e.g.
who is speaking) and the content (e.g. what is said when) of the interaction”,
and using tools may even reduce the need for some language (Gergle et al.

The process of accomplishing mutual understanding between people is
called grounding (Clark & Brennan 1991); in this interactive process indi-
viduals construct and maintain a common ground. The concept has roots in
linguistics and cognitive psychology, and focuses on the use of language to
reach mutual understanding. According to Scholz et al. (2003) language use
is a joint action carried out by people acting in coordination with each other
and it consists of both individual and social processes; however, rather than
focusing solely on the language, the grounding approach also looks at the
ways in which people organize interactions in order to create mutual under-
standing. The environment is also part of this process as it provides the team
members with access to the same information; it allows them to see and hear
the same things (Dillenbourg & Traum 1999).

Grounding is part of a refinement process through which actors refine
what they mean, becoming more and more exact over time (Baker 1995).
They increase the common ground when they add new related information.
This is done through either the tools, the goal, the setting, or the individuals
themselves (Baker et al. 1999). The constraints on achieving common ground, and the costs of doing so, change in the collaborative situation depending on the tools being used; see the section below on appropriation and use of tools.

Face-to-face interaction provides people with many contextual cues such as facial expressions, body postures and gestures that guide them as they interpret others’ communication and interact with them (Goffman 1959). In distributed collaboration, depending on which medium is used, some or all of these cues disappear. Still, research shows, collaborators find it more important to have a shared view of the work than to see each other (Gaver et al. 1993; Kraut et al. 2002). However, if the team members are not sharing the same native language, video is especially important: the picture supports them in showing their understanding through facial expressions and gestures (Veinott et al. 1999).

Propagating ideas and contributing to teamwork

Collaboration is about reaching common goals and to a large extent about sharing. Therefore contributing to the work is important. Clark and Schaefer (1989) say it requires two elements: first, a contributor who tries to specify the content of that contribution, and second, an effort by co-participants to register that content. Making contributions is a collective activity; contributions “emerge only as the contributor and the partners coordinate actions in just the right way” (Clark & Schaefer 1989: 263).

In this work contributions are sometimes discussed in terms of ideas: how can an idea that is launched, either hastily or after careful formulation, be picked up (immediately, later, or not at all), and then grow, transform, change shape or even die over time? Even worse, a good idea may never be expressed because of inhibiting processes within the team due to the group dynamic.

Shneiderman (2000) has created a framework in which he identifies the phases and activities in the creative process. He sees four phases: collect, relate, create and donate. They are complemented by eight activities: searching and browsing digital data, consulting with peers and mentors, visualizing data and processes, thinking by free associations, exploring solutions, composing artifacts and performances, reviewing and replaying session histories, and disseminating results. Shneiderman focuses on designing user interfaces to support single users in their creative work process, but his phases and activities are equally appropriate for understanding ideas and teamwork in a more general sense if digital data is involved. Besides, in most collaborative activities, some stages are characterized by some “creativity”; for instance when a project is starting up teams often explicitly search for new ideas. They can use various techniques to come up with and capture ideas; a classical method is brainstorming. Brainstorming sessions can be conducted in
different ways, such as using post-it notes to write down ideas and then “posting” them on a wall. Another method to help people open up to new ideas is the “six thinking hats” of de Bono (1993): team members take on different roles (factual, emotional, critical, positive, creative and process control) when evaluating ideas; these roles shift between team members.

In any collaborative activity—whether articulated as creative or not—the team members have to make contributions and share their ideas with the other team members to succeed in their teamwork. The crucial point is that the contributions or the ideas are communicated and “registered” by the co-participants; the available tools may support this process.

Appropriation and use of tools

The use of tools is central in human interaction and communication. The most characteristic tool that humans use—and perhaps also the most transparent—is language. Tools may have multiple roles when they are being used. First, tools mediate action: they facilitate activities that otherwise would be more difficult to conduct, or even impossible. Tools can also function as ‘material signals’ (Clark 2005); that is, tools can be used to indicate things and a tool can be used to direct attention to itself.

Fundamental to the use of tools is appropriation, the process of “making something one’s own” (Wertsch 1998: 53). Appropriation may lead to mastering the use of the tool. The difference between appropriation and mastery is that appropriation is connected to a reflective and voluntary action of the actor, while mastery refers to the use of a tool in an automatic and non-reflective way. The appropriation of tools is governed by or limited by the function and the material qualities of the tools; this is true for both physical and digital objects.

Some tools are explicitly created to support communication and collaboration between people. One way to better understand what the tools enable is to classify them. A basic way of doing so is the time-space matrix (Johansen 1988), which divides tools according to whether they support synchronous or asynchronous communication and co-located or remote collaboration. A more specific system for classifying communication media identifies the constraints that a tool places on a range of phenomena: ‘co-presence’ (being located in the same physical place), ‘visibility’ (ability to see the same things), ‘audibility’ (ability to hear the same things), ‘co-temporality’ (whether the medium eliminates delays), ‘simultaneity’ (ability for all parties to interact at the same time), ‘sequentiality’ (flexibility in how turns need to be taken), ‘reviewability’ (ability to review data) and ‘revisability’ (ability to revise data) (Clark & Brennan 1991). If one or more of those characteristics are missing the media pose costs to the actors communicating; then, either

4 In psychology one talks about ‘expertise’ which is similar to mastery.
the addresser, the addressee, or both, have to “pay”. The media can pose costs in many areas, including formulation, production, reception, understanding, and start-up, as well as delay, asynchrony, changing speaker, display, creating and repairing faults (Clark & Brennan 1991).

Tools are not the only resources that direct collaborative activities; as will be shown in the following section, the physical space also has an impact on collaboration.

**Space**

We are … confronted by an indefinite multitude of spaces, each one piled upon, or perhaps contained within, the next: geographical, economic, demographic, sociological, political, commercial, national, continental, global. Not to mention nature’s (physical) space, the space of (energy) flows, and so on. (Lefebvre 1974/1991: 8)

The word ‘space’ is used in a wide range of contexts and disciplines, so it naturally takes on different meanings depending on context. Often space is related to time, following Einstein’s theory of relativity in which space and time are not separate entities, but are fundamentally interwoven. In physics space is not something that is absolute and eternal. Instead relationships define and establish it: a space exists when there are at least two particles, and the movement between them constitutes time. Accordingly, it follows that social space is “relationally constituted out of the simultaneous co-existence of social relations and interactions” (Barker 2003: 349).

Since the 1970s interest has grown in using the concepts ‘space’ and ‘place’ instead of time within social and cultural studies. Traditionally time has been considered as “the dynamic field of social change” and space as “dead, fixed and immobile, traversed by the movement of history” (Barker 2003: 347). Foucault (1986: 22) says that we are living in an “epoch of space”:

> The present epoch will perhaps be above all the epoch of space. We are in the epoch of simultaneity: we are in the epoch of juxtaposition, the epoch of the near and far, of the side-by-side, of the dispersed.

Foucault’s point is that it is space and not time that is essential in the contemporary cultural and social analysis (Benwell & Stokoe 2006). In other words, those who are theorizing about social processes have turned from temporality and the historical towards spatiality and the geographical (Soja 1989).

In the present work it is particularly important to understand the physical space as a social space in order to understand how collaborative activities are
unfolding and carried out. In this section the physical aspects of space will be presented in light of the social aspects, and followed by a discussion of space and collaboration. First, however, a short introduction to the relationship between ‘space’ and ‘place’ should prove useful.

**Understanding space and place**

When talking about ‘space’ it is almost impossible to avoid mentioning ‘place’; writers in several disciplines talk about ‘place’ rather than ‘space’ when discussing where people interact and activities occur. Harrison and Dourish (1996: 67) make a useful distinction: “space is the opportunity; place is the understood reality”. More precisely this means that ‘space’ is what is around us, as an opportunity, and it is the ‘place’ that frames our activities through their social meanings. Space refers to something more abstract than place (Tuan 1977; Augé 1995; Cresswell 2004); space is open, empty and a possibility for the future, while places have a history and a present; something has already been achieved there (Tuan 1975). Tuan (1977) believes that we cannot define ‘space’ without ‘place’ and vice versa. According to Cresswell (2004: 10) ‘place’ is a ‘space’ that is given meaning by people:

> Space … has been seen in distinction to place as a realm without meaning – as a ‘fact of life’ which, like time, produces the basic co-ordinates for human life. When humans invest meaning in a portion of space and then become attached to it in some way (namning is one such way) it becomes a place.

The idea that a place has meaning may lead people to feel, personally, that they are in-place or out-of-place (Cresswell 2004). However, a ‘place’ is not fixed and static: it is “made and remade on a daily basis”, and is “never finished but always a result of processes and practices” (Cresswell 2004: 39, 37). Tuan (1975) points out that it takes time and deep engagement to know a place, because our knowing is based on our experience with it.

**Physical space as social space**

According to Tuan (1977: 102) architecture is the “key to comprehending reality”, because the body is influenced by architecture and the spatial dimensions of an environment affect our awareness. Hall (1966: 60) also describes the close relationship between humans and our environment:

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5 Other authors discuss ‘non-places’ (Augé 1995) and ‘placelessness’ (Relph 1976). ‘Non-places’ appear to have no history and are transitory, used for moving between places (like highways, airports, supermarkets, etc.) The concept of ‘placelessness’ is slightly more complex and is connected to having an inauthentic attitude; these thoughts are derived from Heidegger.
Man’s sense of space is closely related to his sense of self, which is in an intimate transaction with his environment. Man can be viewed as having visual, kinesthetic, tactile and thermal aspects of his self which may be either inhibited or encouraged to develop by his environment.

Hall (1966) introduced the term ‘proxemics’ to talk about the ways people use space. Some physical aspects of ‘space’ have fixed features, such as buildings and the design of public spaces, and some have semi-fixed features; consider the flexibility within space that makes it possible for individuals and groups to organize themselves. What Hall calls ‘informal space’ plays a crucial role when we are interacting with each other. Depending on our social context, culture, and personality we keep different distances from those around us. Hall (1966) distinguished between four zones (the estimations of distances are in parentheses): intimate distance (close to eighteen inches), personal distance (one and a half to four feet), social distance (four to twelve feet), and public distance (twelve feet and more).

Intimate distance is reserved mainly for the closest relationships; in its closest phase it involves physical contact. In the personal distance the two people are close enough to touch or grasp each other, but a small distance exists between them. When it comes to social distance the closest phase is used by people working together or at social gatherings; in ordinary business and in more formal social conversations the distance is a bit larger. Finally, the public distance dramatically changes the individual’s involvement because the sensory input is very different (one needs to speak more loudly, cannot see as sharply, etc). People are perceived as impersonal and relatively anonymous. Greater distances, over thirty feet, are often set up for important public persons.

Another way of approaching social space is to study territoriality, that is, to consider how people define and maintain their possession of objects and areas (Sack 1986). Territoriality is based on the idea that space is socially constructed and the social is spatially constructed (Barker 2003: 291). Just like animals, humans mark territories physically. We use central markers for objects we reserve for ourselves personally, while boundary markers separate one person’s territory from those of others, and still other markers indicate the possession of a territory or object. Sack (1986: 19) defines territoriality as

the attempt by an individual or group to affect, influence, or control people, phenomena, and relationships, by delimiting and asserting control over a

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6 Hall’s ‘distance zones’ result from observations and interviews in the northeastern United States and are neither absolute nor general.
7 Similarly Lefebvre (1974/1991:26) states that “(Social) space is a (social) product” (italics in original). To understand the use of product there one must consider Lefebvre’s work in the light of Marxism.
geographic area … territories require constant effort to establish and main-

tain.

From a biological perspective all creatures are fighting for space: we need to have our own space to avoid being attacked. From a social perspective, however, humans are social beings who need to interact and communicate with others to survive; territoriality is a product of social context. This situation leads all of us to constantly negotiate for space.

Yet another way to investigate the idea of social space is to look at how people act and interact when they are together. Goffman (1959) uses the terms ‘front region’ and ‘back region’ (or ‘backstage’) to illustrate how human interaction is performed.\(^8\) When we are in the front region we are displayed to the others and when we are in the back region we can relax. According to Goffman (1959: 32-33) the ‘setting’ is the scenic part. It involves furniture, décor, physical layout, and other background items which supply the scenery and stage props for the space of human action played out, before, within, or upon it.

In any situation, Goffman says, we are ‘giving off’ expressions that others interpret. To protect ourselves when we are in the front region we can hide behind a façade. More precisely, we are trying to give off and maintain an idealized picture of ourselves for the others: we are accentuating the positive parts of our personality, and suppressing others. An actor takes on an appropriate (social) role—usually an already existing one—when performing. Keeping the façade consistent is tiring; this is one reason why we need to go backstage from time to time. Backstage, the character and behaviors may be more or less contradictory to those being shown on stage.

These phenomena also account for teams. Within a team the members take on various roles. Often someone on the team has the right to direct the team and control how the work will proceed. Other team members take on other roles. Within the group any individual can only maintain a personal façade to a certain degree; complete control is impossible. However, for the team the important thing is that the team’s overall effect is satisfactory, that is, that they project a satisfactory image of the team to the surrounding world. It would be too difficult for a team member to simultaneously maintain a certain image impression among all the others within the team.

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\(^8\) Goffman (1959) uses the term ‘performance’ when an individual is acting in front of and being observed by others.
Spaces for collaboration

Not only do people make spaces, but also spaces make people. (Benwell and Stokoe 2006: 211, italics in original)

Spaces are not neutral (Benwell & Stokoe 2006). The physical and the social cannot be regarded as two isolated aspects of space, as the social relies on the physical conditions. They are two separate aspects that are closely intertwined and they depend upon each other. The physical space offers certain conditions for the social space, such as the possibility of moving between different distances (following Hall 1966) or shifting between the front and back region (Goffman 1959). Also, the ways that people occupy their territories (Sack 1986) depend on the given physical space. As a result of this interrelationship between physical and social space, people must simultaneously relate to both kinds of space when they are interacting and collaborating. In an ideal situation the physical space and the social space are transparent so that the team members can focus on the task at hand.

The physical space—the architecture, the available artifacts, the layout of spatial and material resources, etc.—sets the context for where and how the collaboration can unfold and be manifested. The physical qualities of the space influence the way people may or may not be able to interact with each other: how they can share the view, information, objects, etc. Even if people are flexible and innovative in developing strategies, rules, routines and conventions for overcoming problems, the physical space can be more or less supportive (or disruptive) of collaborative activities.

When actors are situated in a new environment they have to become acquainted and familiar with the new elements that are part of the new space. This is an important step towards not feeling out-of-place (Cresswell 2004). People need to appropriate new artifacts so they can take part in future activities.

As already has been emphasizing, social space is partly constructed by physical conditions; however, like ‘territoriality’ (Sack 1986), space is also socially constructed (Massey 1994, 2005). Massey (1994: 2) thinks about space in relation to time:

…not as some absolute independent dimension, but as constructed out of social relations: … what is at issue is not social phenomena in space but both social phenomena and space as constituted out of social relations, … the spa-

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9 Benwell and Stokoe (2006) focus on space in relation to identity construction, but their statement is also valid in this context.
10 Mastering certain artifacts may be especially important when it comes to power and the division of roles between team members. Though team members’ roles are important to this discussion, they are not considered in the light of power and power relationships.
tial is social relations ‘stretched out’. The fact is, however, that social relations are never still; they are inherently dynamic.

The account thus far has not mentioned the single individuals taking part in collaborative activities. My aim has not been to exclude the individuals from the factors that influence collaboration. Certainly it makes a difference who the specific team members are when it comes to how they are collaborating, how they perform as a team, how they share activities, which social conventions are formulated, who controls and masters which tools, etc. A single team member may have an immense impact on the rest of the group when it comes to the specific ideas that emerge or to the performance of work. However, these aspects fall outside the scope of this work.

Interactive spaces

The traditional approach in studying human-computer interaction is to focus on the interaction between a single user and an artifact. The workspace changes considerably when many users are in a space with many artifacts, and it changes even more when information can be displayed in public as well as in private.

Ubiquitous computing is an important concept here. The terms pervasive computing, ambient computing and calm computing also describe the same phenomena. That is, people started by using only desktops (or laptops), but technologies have emerged (and will continue to do) that have become more and more invisible and embedded in the environments. Ultimately the technology disappears into the environment, but becomes visible when needed.

Weiser (1991: 94) defined ubiquitous computing as a “new way of thinking about computers in the world, one that takes into account the natural human environment”. Central to his vision was a natural interaction between humans and computers, without the human thinking about it in any detail. Computers would become part of the background, spread out in the environment, and be indistinguishable from the fabric of everyday life. Users should get the feeling that they are interacting with the environment as a whole and not with separate computing devices. In designing and constructing such environments it is important to have a global vision, and part of that vision is that the users are interacting not with single objects but with the environment. This way of viewing technology and of interacting with resources leads to a broader way of thinking about design (cf. Weiser 1991; Mackay 1998). Prototypes of environments that implement, demonstrate and exemplify these ideas can be found in Streitz et al. (1999), Krogh and Grønbæck (2001), Werle et al. (2001), Johanson et al. (2002), Rogers et al. (2002), Scholz et al. (2003), and Lahlou (2005). However, as Rogers (2006) points out, so far ubiquitous computing (or calm computing) has had disap-
pointing results. Advocates of ubiquitous computing may learn from artificial intelligence (AI), where weak AI has been successful, and strong AI has not. Likewise, ubiquitous computing should formulate more practical goals and move from the ambition of creating a “smart and proactive” space to “one that enables people, themselves, to be smarter and proactive in their everyday and working practices” (Rogers 2006: 418).

In this work the term ‘interactive spaces’ refers to environments that support co-located and distributed collaborative work and that include both shared and private displays. Interactive spaces also offer users several different ways to create, present, and share data with the other team members. For instance, touch-sensitive displays allow users to interact with the computer using an ordinary mouse and keyboard, but they can also use their fingers or a special pencil to write, draw, or navigate directly on the displays. The motivation for having such spaces is to let the tools enhance the collaborative activities one wants to carry out.

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11 The difference between strong and weak AI is that strong AI claims that computers can be conscious, whereas weak AI makes no such claim. More practically, researchers taking the strong position in AI say that systems that act intelligently have conscious minds, but in weak AI they say that systems can act as if they were intelligent.
This chapter provides an overview of the settings where the two studies were conducted. The research issues are then discussed in greater depth and the research questions are presented.

Overview of the settings

The two studies took place in similar but not identical settings. In both studies the team members could use large shared displays in combination with private displays and software tools that enabled them to share information. The first study focused on co-located collaboration and took place in iLounge, an interactive space at the Royal Institute of Technology in Kista, near Stockholm. The setting for the second study was a ‘space’ used for geographically distributed meetings; the teams were spread across Europe and North America. Here, each participating team had its own distinctive interactive space, and for the meetings they used a common set-up, which formed a common space for their collaboration. This section is divided into two parts, each describing one setting.

The setting of the first study

The first study took place in iLounge which was designed and built for the purpose of supporting co-located collaborative and distributed work. It is used both as a learning facility and as an experimental research facility. The room has two large touch-sensitive displays, known as Smart boards (from SMART Technologies), built into a wall. In front of this wall is a table with a horizontally embedded plasma display, also touch-sensitive, which is large enough for 6 to 8 people to sit around. In one corner of the room a smaller table and three chairs are placed in front of a wall-mounted plasma display; this makes it possible for teams to divide up their work, but still be in the same physical environment. Figure 1 shows a plan of the room. The room has a wireless network and at the time of the study a laptop computer with a wireless LAN card was available. Keyboards and mice in the room are also wireless, using Bluetooth technology. Finally, iLounge has high-quality au-
dio and video equipment that can be used during videoconferences or user studies.

When teams are working in a space with multiple displays (computers) it is not obvious how information is shared between the different work surfaces. To facilitate and support work in the iLounge our research group has been focused on developing software tools that help the user to move data between the devices. When the study was conducted, four software tools were available for sharing information between displays in the room: Tipple, Multibrowse, Pointright and iClipboard.

![Figure 1. Plan of the room. The working areas are marked in blue.](image)

Tipple is a tool with which a user can open any file on any other computer that runs the Tipple service. The Tipple interface shows icons representing all the other computers running the service. A user who wants to start a file on another computer simply drags the file icon to the icon representing the other computer.\(^\text{12}\)

Multibrowse allows the user to move web content between displays in the room. By right-clicking on a page or a link, the user can “multibrowse” the content to or from its present location.\(^\text{13}\)

PointRight makes it possible to use the same pointing device or keyboard on more than one computer in the room. When the pointer reaches the border of the display it continues on the display next to it that also runs the service. In combination with iClipboard, PointRight makes it possible for the user to cut or copy text between computers in the space. The text is placed on a clipboard that is shared by the computers running the service.\(^\text{14}\)

\(^\text{12}\) An early prototype is described in Werle et al. (2001).
\(^\text{13}\) Johanson et al. (2001) describe Multibrowse more thoroughly.
\(^\text{14}\) Johanson et al. (2002) describe PointRight more thoroughly.
In the study the participants were also introduced to some SMART Technologies tools, specifically the virtual keyboard and Smart Notebook. Smart Notebook is an electronic whiteboard application; it allows users to create documents containing typed text, hand-written text, and pictures. The document appears on the electronic whiteboard as a book with pages.

Figures 2a and 2b show a team working in the iLounge using the different displays for different purposes.

**Figure 2a.** Individual information search

**Figure 2b.** A team is discussing their storyboards

The setting of the second study

The setting in the second study depended partly on the local conditions, but to carry out the meetings the teams used a common setup, which created a shared space. To transmit video and audio they used a multiplex videocon-
ferencing system; an audio conference system was available in case the video link failed (or if someone who was not in the office wanted to connect).

To share information they had access to a shared media space and a wiki\textsuperscript{15} website; both were accessible on the Internet. They mainly used the wiki site to store internal information about the team members and the labs, along with meeting dates and agendas; this information was primarily used between the meetings. General information is also available to individuals visiting the page. The media space, on the other hand, was used as an information resource, a place to which they could upload and download documents such as their presentations and working documents.\textsuperscript{16} They also used it during the meetings as a shared virtual workspace where everyone who is logged in can work simultaneously; a restriction was that only one person at a time was able to manipulate a document. To provide silent support during the meetings an instant messenger was used; users logged on before the meetings began.

The laboratories normally used two screens to display different information: one that showed the team members who were present on video and the other that displayed the shared media space. Usually at least one of the displays was large.

Figures 3a through 3d show the meeting situation at four of the laboratories that participated in the study.

\textsuperscript{15} Wiki is a type of server software that allows invited users to create, add and remove web page content while using any browser (http://wiki.org/wiki.cgi?WhatIsWiki)

\textsuperscript{16} See Lahlou (2005) for a more thorough description of the media space used at the meetings.
Research issues elaborated

In the next section the first two research issues are articulated as seven research questions; then the third research issue is briefly elaborated.

The first research issue: In what ways are team members allowed to contribute to the overall teamwork?

In this work one characteristic of collaboration is key: that team members are striving towards shared goals, which can be more or less clear and well-formulated. Another important characteristic is that, to a large extent, collaboration is about sharing, which is done in several ways, and it is also important to consider what is actually shared. That is, team members need to share goals, information, knowledge, understanding, etc. and to do so they must contribute. How and in what way the team members are able to contribute to the work depends on the relationships between the members, but also on the environment in which the collaboration takes place and the available tools. In this thesis the focus is on the latter aspects: the physical qualities of the interactive space. An obstacle may arise if the actors are not familiar with the tools or do not know how to use them; then they need to appropriate them before they can collaborate in a meaningful way. In this work
appropriation means “making the tools one’s own”; this is an ongoing process and not specific to certain situations. In a distributed setting like the second study, the team members are placed in a more complex situation than the face-to-face interaction of the first study. The setting provides the team members with fewer contextual cues (depending on which media are used); consequently, performing the teamwork in a fluent way takes more than simply knowing how to use the tools, or having appropriated them. The team members may need to learn new routines or new conventions to handle the situation, and to make contributions comfortably; this learning is one way to appropriate the setting or to make the setting one’s own (cf. Goffman’s (1959) notion of ‘setting’).

To approach the first research issue five questions were stated. Two questions concern the role and use of the tools as means for making contributions when collaborating in the interactive space: [1] How do the tools support the team members in contributing to the overall work? [2] How do the team members appropriate the tools so they can contribute? The first question is relevant in three of the analyses of this work (presented in papers I through III). The tools have slightly different roles in the two studies. In co-located collaboration the tools offered a possibility to enhance the way the team members could collaborate, interact and contribute to the overall work. In the second study, where team members collaborated from a distance, technological support was needed to make the collaboration possible at all. The second question is applied to the first study (paper II), where the team members had to use the tools (particularly the large wall displays) if they were to make progress on the task.

The third question focuses on the propagation of ideas and the setting: [3] How does the physical layout of the space impact the propagation of ideas? This question was asked in the first study (paper I); in this situation all the team members were working in the same physical space. The phrase ‘propagation of ideas’ refers to the ways that ideas evolve over time: how they are launched and picked up, how they grow and transform, etc.

The fourth question concerns the distributed collaboration: [4] How does the mode of participation influence the way contributions are made? In the distributed collaboration it was possible for team members to attend the meetings using both video and audio or by audio only (the backup channel); paper III investigates what that meant for the participants as they contributed to the collaboration.

Finally, a fifth question addresses the understanding of how the teams in the distributed setting managed the situation: [5] What kind of social conventions do the teams create for their collaborative activities? Team members use conventions to coordinate activities. In a distributed setting with a number of constraints on how members can interact and communicate—a situation related to restricted contextual information—it is not possible to rely
solely on existing conventions (those that are used in face-to-face interaction) in making contributions. This question is investigated in paper IV.

**The second research issue: How do the team members handle roles and functions in the collaboration?**

Often one purpose of teamwork is to make use of, and benefit from, the team members’ different competences. Team members often divide up the roles among themselves, taking on assignments either explicitly or implicitly. Which roles or functions they take on depends not only on personalities, but also to some extent on the tools and the environment where the collaboration takes place. Moreover, as in the second study, the roles can be influenced by the participation mode (i.e. video and audio, or audio only).

Two further questions were developed from the second research issue. The first one is: [6] *How do the tools impact the team members’ role assignments?* This question is relevant in any collaborative situation where tools are used,\(^{17}\) and is asked in the analysis of the two data sets (papers I and III). The second question is: [7] *How does a “distributed” location influence the role one can take in the collaboration?* This question addresses what it means to have a “distributed” location in relation to the role one is assigned within the team. This question is a bit similar to the previous one (question 6) in that the participation mode depends directly on which tools are used as communication channels (i.e. video- or telephone conference). However, question 7 focuses solely on the reality of having to contribute from a distributed location. In the second study the participants were working in one of three potential modes: video and audio, audio-only and “co-located”. The latter mode occurred in one meeting when all but two teams were situated co-located. Question 7 is investigated in paper IV.

**The third research issue: How do the physical qualities of the interactive space impact the collaborative activities?**

As a result of the analyses of the studies a third research issue emerged because the physical qualities of space seemed to play an important role in the collaborative activities. That is, the tools, the material qualities of the tools, the layout of the space and the architecture seemed to influence how the team members came to contribute to the overall work and how the roles and functions were distributed between them. The analyses in papers I through IV indicated that the physical is a social space (cf. Sack 1986; Lefebvre 1974/1991; Massey 1994, 2005). This issue is investigated in Paper V and the analysis is based on the results presented in the first four papers; this also means that the analysis is based indirectly on the seven research questions.

\(^{17}\) Even in a situation where the only tool used is (spoken) language. Bourdieu (1991) has thoroughly analyzed the ‘symbolic power’ of language. In this study, however, the focus is on the physical and digital tools.
This chapter describes several approaches and methods that have been found useful in this work for studying and analyzing human interaction. As they are all in one way or another related to ethnomethodology (Garfinkel 1967), that approach will be described first. Ethnomethodology is followed by a section on conversation analysis, an approach that grew out of ethnomethodology but has, over time, developed a research program of its own (Lynch 1993). Then, a more specific method within conversation analysis is described: initiative-response analysis. This method does not derive directly from ethnomethodology and conversation analysis; its theoretical base can be found in ‘language game analysis’ (Severinson Eklundh 1983). However, initiative-response analysis is discussed within conversation analysis because its unit of analysis is the turn. The turn is also one of the most important features in talk found by the conversation analysts. However, this work focuses not only on verbal communication but on the interaction as a whole, including its non-verbal aspects and the use of tools; this is considered in the third section. The method of interaction analysis, as formulated by Jordan and Henderson (1995), provides practical guidance in how to approach and conduct the analysis of human interaction that is based on video data. The final section is exclusively devoted to the process of transcribing, which is an important activity for conducting in-depth and micro-level analyses of social action. Transcriptions, the outcome of the transcribing process, are used both to conduct the analysis and to present the data to others.

**Ethnomethodology**

Ethnomethodology studies the methods people use to create and make sense of their ordinary social life (Garfinkel 1967; Heritage 1984; Lynch 1993). It focuses on the common-sense reasoning that people use to accomplish their everyday activities. Key concepts are ‘indexicality’, ‘reflexivity’, ‘accountability’ and ‘the documentary method of interpretation’.

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18 Ethnomethodologists use the term ‘member’. A member is a person who has “embodied the ethnomethods of a particular group” and who “naturally exhibits the social competence that affiliates her with this group, allowing her to be recognized and accepted” (Coulon 1995: 27).
‘Indexicality’ means that the meaning of a word or utterance depends on its context. That is, we must understand the situation (context) in which the sentence is uttered, not just the words themselves: the words are “indexed” (Coulon 1995: 17). Ethnomethodologists are not content merely to identify the context on a general level, saying, for instance that a discourse is taking place in a classroom or a court; they also want to understand the specifics of the situation in which the actors are engaged. Thus, to understand the sense of an utterance one must understand both the words and the context.

The second principal concept is ‘reflexivity’. The idea behind reflexivity is that “descriptions are not just about something but they are also doing something” (Potter 1996: 47, italics in original text), which means that utterances are not only descriptive, but they also have practical consequences in that they formulate the action and the situation (Potter & Wetherell 1987). ‘Accountability’ is related to reflexivity. The idea is that actors organize their activities in such a way that they are “detectable, countable, recordable, reportable, tell-a-story-aboutable, analyzable” (Garfinkel 1967: 33). In addition, other members can “observe and report, that is, make sense of, the action in the context in which it arises” (Dourish 2001: 79).

Finally, ‘the documentary method of interpretations’ refers to the methods people use to make sense of the world (Garfinkel 1967). That is, to understand events and actions, people use background expectations, models and ideas. We modify these expectations when we gain new understandings, which is a constant process. Pollner (1987) expressed a very similar idea about mundane reasoning: we make simple assumptions about the world that are based on our own (empirical) experiences and we use these assumptions when communicating and interacting with others. Minimally we think that we all have potential access to the same underlying reality, a concept called ‘reciprocity of perspectives’ (Schütz 1962).

In Computer-Supported Cooperative Work (CSCW) researchers often speak of ethnography or ethnographic methods when in fact it would be more correct to talk about ethnomethodological ethnography (Shapiro 1994).19 One reason for this confusion is that ethnomethodologists often borrow research techniques from ethnography (Dourish & Button 1998). The present study is influenced by ethnomethodology. The insights about indexicality, reflexivity and accountability in ethnomethodology have been important in determining how to study interaction and collaboration between people.

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19 According to Heath and Luff (2000) ethnomethodology and conversation analysis may have had the greatest influence on the emergence of workplace studies.
Conversation analysis

Since it grew out of ethnomethodology in the 1960s and 1970s, conversation analysis has become very extensive and has had a significant influence on other disciplines in the social sciences including linguistics, social psychology, anthropology and cognitive sciences (Heritage 1984). Conversation analysis studies ‘talk-in-interaction’, that is, language use that occurs naturally (Schegloff 1996). It seeks to describe

…the underlying social organization—conceived as an institutionalized sub-stratum of interactional rules, procedures, and conventions—through which orderly and intelligible social interaction is made possible. (Goodwin & Heritage 1990: 283)

A basic assumption of conversation analysis is that “ordinary talk is systematically and strongly organized” (Atkinson & Heritage 1984: 17); it aims to reveal the organizational features of talk and show how actors produce and make sense of talk. It seeks both to account for the observable regularities that aggregate the data (in language use) and to formulate analytic resources to understand single cases that are situated in a context (Schegloff 1996). The early studies primarily studied telephone conversations and institutional talk, for example in courts and between doctor and patient, but over time conversation analysis has also come to be applied to casual conversations. It is based on audio- and videotaped everyday conversations that have been transcribed and analyzed in detail.

Turn-taking is fundamental for organizing talk. A turn may be taken if one speaker stops or pauses and another person starts to talk. Or, the current speaker may select the next one or be interrupted by another.

One way that turns in talk are sequenced is in ‘adjacency pairs’ such as greeting-greeting, question-answer, congratulations-thanks, apology-acceptance, inform-acknowledge, and leave taking-leave taking. Adjacency pairs do not have to be directly coupled; other turns may be embedded in between. The second part of the pair can either be preferred (e.g. acceptance) or not preferred (e.g. refusal); this is referred to as ‘preference structure’. Adjacency pairs have been shown to be important for starting and closing conversations.

Talk-in-interaction is usually ‘other-directed’ (ten Have 1999). The co-participant plays an important role, since the interactions aim to develop understanding between the actors. The “exhibited understanding” (Schegloff 1993: 101) or the responses given by the co-participant are important elements in how the interaction unfolds. Co-participants can display understanding by uttering “yeah”, “mm hm”, “uh huh”, and the like, indicating

20 As opposed to written texts, monologues, etc.
that the speaker can continue to talk. But the co-participant may also interpose a “huh?” or a “what?” to indicate that something is not clear. A repair occurs when a co-participant (listener) does not understand something or if the speaker is not sure if the listener follows the conversation. A repair can be initiated by either the speaker or the “other” and can happen at any time (Schegloff 1993).

For the present study conversation analysis has been helpful in understanding the basic mechanisms in communicative activities, such as the role of turn-taking and repair.

**Initiative-response analysis**

Initiative-response analysis, conceived by Linell and Gustavsson (1987), examines ‘communicative activities’ (dialogue or multiparty conversation) in terms of initiatives and responses. The unit of analysis is the turn, and each turn is categorized as either an initiative or a response. It is a useful model for understanding the global aspects of communicative activities in which the turns are relatively short.

The initiative is an attempt to request, claim, or dominate and it refers forwards; the response refers backwards, and can be more or less immediate. In contrast to many other theorists, such as Sinclair and Coulthard (1975), Linell and Gustavsson (1987) do not talk about ‘follow-up moves’ or evaluation of utterances. Instead they believe that every utterance can be defined as either an initiative or a response; compared for instance adjacency pairs in conversation analysis, the initiatives and responses are abstract units.

Ethnomethodology influenced initiative-response analysis through one key insight: that the interaction between actors is created on a turn-to-turn basis (Linell & Gustavsson 1987). Its influence is also reflected in the initiatives and responses in that each turn is both context-shaped and context-renewing (Heritage 1984: 242); that is, each turn (or action) is rooted in its current context but simultaneously contributes to the next. Communicative activity continues constantly.

Linell and Gustavsson (1987) have developed an 18-category system for coding communicative activities. Each category represents a particular combination of initiative and response features, and each turn is carefully evaluated in relation to the specific categories. These 18 categories can be ordered on a six-point scale that evaluates how strong or weak they are. An

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21 Schegloff (1982, 1993) prefers to talk about ‘continuers’ while others call these kinds of tokens ‘backchannels’.

22 Initiative-response analysis is described in English in Linell et al. (1988).

23 Talk and action shape context and simultaneously renew it; this is referred to as the reflexive character of talk (Koschmann et al. 2007).

24 Note that the use of categories is not ethnomethodological (cf. Koschmann et al. 2007).
initiative that scores ‘6’ is at the strongest level without any response properties whatsoever and a response that scores ‘1’ is inadequate.

Related to the work of initiative-response analysis, Korolija (1998) has studied ‘episodes’ in talk. Episodes are natural units of conversation and they are important for constructing coherence in communicative activities (Korolija 1998). Episodes separate one ‘project’ (Clark 1996) from another. A project is kept together by topic or activity. Most episodes are topically coherent, but they need not be; a quiz is an example of a non-coherent episode (Korolija & Linell 1996).

Initiative-response analysis was used in the analysis of the second study. It has been found useful for understanding the global aspects of how communicative activities proceed.

Interaction and video analysis

The approaches and methods described so far have mainly focused on verbal communication. But communication and interaction also involve gestures, gazes, the use of tools, etc.; these all indicate, illustrate and guide interpretations of the spoken accounts. Interaction analysis (Jordan & Henderson 1995) is an interdisciplinary method for making micro-level analyses of how people interact with one another, their physical environment, and their tools.

The principal way of collecting data is by making video recordings. Video has many advantages. First, it makes it possible to view an interaction as “another next first time” (Garfinkel 2002: 98), which is “a powerful corrective to our tendency to see in a scene what we expect to see” (Suchman & Trigg 1991: 76). Collaborative viewing of video material is a way of “neutralizing” the researcher’s “preconceived notions” (Jordan and Henderson 1995: 44). Video also makes it possible to go back to the data and check what people actually are doing, rather than rely on what they say they are doing (Ruhler & Jordan 1997). The recordings make it possible not only to re-view the data, but also to view and analyze the sequences in slow motion or frame-by-frame (Büscher 2005).

The positioning of the camera is crucial and requires analytical reflection: each position favors some views and excludes others (Goodwin 2000). Similarly, if a movable camera is used, the cameraman is continuously deciding what to focus on; this becomes a constraint when the researcher begins to analyze the recordings (Mondada 2006).

To approach the video material interaction analysis suggests a number of foci as a “way-into-a-tape” (Jordan & Henderson 1995: 56). These foci include both global and more detailed aspects of the interaction; examples are

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25 It is also possible that the analyst sees and hears other things than those the participants do themselves (Jordan and Henderson 1995).
structures of events (i.e. beginnings and endings, and segmentation of events), temporal organization of activity, turn-taking, participation structures, trouble and repair, spatial organization of activity, and artifacts and documents.

Koschmann et al. (2007) present a “manifesto” for the video analyst; in five ‘policy statements’ based on Garfinkel (1967), they articulate the implications for video analysis. Their five policies are ‘indifference’, ‘contingently-achieved accomplishment’, ‘relevance’, ‘accountability’, and ‘indexicality’.

‘Indifference’ means that any instance of social action is as good as any other for the purposes of understanding how social action is organized. Not only will any instance do for demonstrating a phenomenon of interest; in fact, a demonstration can be based on a single case. They base this statement on the assumption that human interaction always constructs a meaningful order.

‘Contingently-achieved accomplishment’ points out that actors are continuously engaged in interaction as it is performed and unfolds; interaction is not predetermined, and therefore the interaction must be sequentially analyzed.

‘Relevance’ refers to the fact that categories should only be introduced if it is possible to empirically demonstrate their relevance in the interaction through talk. This policy leads them to question the common practice in discourse analysis of using pre-defined categories.

‘Accountability’ points out that the video analysts must show how the actors take account of the actions of others.

Interaction analysis has been a useful method in this study because it was developed to analyze how people interact with one another, and with tools and the physical environment. Practically, it provides guidance in how to approach video-recorded data, which is rich in information, and how to analyze interaction, which is a complex task. The analytic foci have proven helpful as a way to divide one’s attention when doing the analysis. For instance, much like conversation analysis, interaction analysis identifies ‘breakdown’ as an important stance: breakdowns reveal problems actors are facing in the interaction. To overcome a breakdown the actors have to repair their conversation, which also reveals the nature of the social action. I am also grateful for the work of Koschmann et al (2007) in making concrete some of Garfinkel’s (1967) ideas, for instance ‘indifference’ and ‘relevance.’ Those ideas helped in this work during the analysis and in the discussion of results.
Transcribing the data material

A transcription is a written form of spoken discourse. Transcriptions have been used and developed in linguistic research for over 30 years (Lapadat & Lindsay 1999; Potter & Hepburn 2005); they have also been adopted by other disciplines, including psychology, sociology, anthropology and ethnography (Lapadat & Lindsay 1999; O’Connell & Kowal 1999). Today many systems exist for transcribing spoken language and interaction, each focusing on different features of verbal communication. The simplest forms of transcripts include only the spoken words, while others reveal much more about how it is said (pauses, overlap, emphases, volumes, and so on). Some researchers have made more elaborated attempts to represent particular qualities in communicative activities such as laughter (Jefferson 1984) and crying (Hepburn 2004). Transcripts can very widely in their length and level of detail, depending on the objective of the analysis (Linell 1994).

A transcription is a tool for the analysis (Linell 1994), which is one representation of the corpus. There is no such thing as an objective or neutral transcription (Psathas & Anderson 1990; Bucholtz 2000; Smith 2005) and the process of transcribing is itself “neither neutral nor unproblematic” (Linell 1994: 3). In the same way that a video camera limits what is captured, transcriptions restrict what they can represent; nevertheless they make the data accessible to other people (Du Bois 1991). There are two types of transcriptions: those prepared to facilitate analysis and those used to present the data (Linell 1994; O’Connell & Kowal 1994).

The process of transcribing is “time consuming and tedious” but the positive outcome is that the researcher becomes closely acquainted with the data (Psathas and Anderson 1990: 77). Linell (1994: 14) recommends making basic transcriptions of the whole record and more precise transcriptions for interesting parts. Another approach, prescribed in interactive analysis (Jordan & Henderson 1995: 10), is to make content logs of the whole data set and transcriptions of the parts that “emerge as significant”. Interaction analysis has a rather liberal view of making meaning from transcriptions: “analytic interests” should drive decisions on how much detail to include in a transcript (Jordan & Henderson 1995: 49).

As mentioned above many parallel transcription systems exist, each created to cover particular purposes or qualities of the interaction. One of the systems most commonly used within conversation analysis is the “Jeffersonian” transcription system (described in e.g. Jefferson 1984; Atkinson & Heritage 1984; Psathas & Anderson 1990). There are many similarities between its transcription and notation systems, but also many differences on a detailed level. Those who say that they are using the Jeffersonian system also use a variety of practices (O’Connell & Kowal 1994, 1999). Selting et al. (1998) have attempted to develop a common style for making basic transcriptions where the user can add new conventions when needed. The probl-
lem is, however, that researchers and transcribers agree on very few of the symbols (Fletcher & Garman 1995). Another objection to a universal notation system is that “it cues the reader to a particular type of reading” (Smith 2005: 310). Instead of trying to create a standardized system O’Connell and Kowal (1994: 102-103) have worked out few essential principles to follow when making transcriptions:

1. Unitary function of notation: Use a systematic notation throughout the transcription; always use the same symbols for the same phenomenon.
2. Integrity of word units: Eliminate the use of supernumerary lettering or punctuation within the words.
3. Description of non-phonological phenomena: Non-phonological acoustic phenomena, such as laughter, should be described rather than transcribed using special syllables, tokens or supernumerary lettering.
4. Measurement: Avoid pseudo-exactitude; that is, avoid using numbers that do not reflect precise measurements.
5. Parsimony: Transcribe only the features that systematically contribute to the analysis and present to the reader only transcriptions that make the analysis intelligible.

Despite what has been said so far O’Connell and Kowal (1994) stress that the primary goal is not a readable transcript but one that is usable for the purpose of the analysis. Transcripts may also contain information about non-verbal behaviors and activities, such as body position, gestures, gaze, and object manipulation (Jordan & Henderson 1995), which the analyst needs to understand the interactional organization between actors and their resources (Suchman & Trigg 1991).

26 O’Connell and Kowal have refined the principles over time. In their 1999 paper they also present five principles, very similar to those presented here, but in their 1994 paper they describe the principles in a less complicated way.
This chapter summarizes the results that are presented in the five papers included in the thesis. Papers I and II report on the first study, which focuses on co-located collaboration; papers III and IV report on the second study, which focuses on geographically distributed collaboration. The analysis in Paper V is based on the results presented in papers I through IV.

Paper I: Backdoor Creativity – Collaborative Creativity in Technology Supported Teams

Paper I reports on the study on co-located collaboration in the interactive space called iLounge. It aims to answer the following three research questions: [1] How do the tools support the team members in contributing to the overall work? [3] How does the physical layout of the space impact the propagation of ideas? And, [6] how do the tools impact team members’ role assignment? In this paper the ‘propagation of ideas’ is discussed in terms of how the creative interactions emerge.

Method

General description of data

Five female and four male students, aged 21 to 45, divided into two teams, participated in the study. One team consisted of three men and one woman, and the other team of one man and four women. Within each team, two or three members were already acquainted with one another.

The students were attending a course in the design of interactive systems at our department. Their assignment was to design a digital, multimedia guide for the exhibition “4.5 Billion Years: The History of Earth and Life” at the Swedish Museum of Natural History. Each group was responsible for designing a different section of the multimedia guide, either “From Big Bang
to First Life”, or “Pre-historic Mammals”. The target group was children about twelve years old.

We followed the students during the conceptual design phase, which lasted two weeks and consisted of brainstorming, searching for information, sketching and making storyboards. During this time the groups had four and five sessions, respectively, in the iLounge. Before they actually used the environment, they attended an introductory session about it.

**Data collection**

Data were collected through video recordings, participant observations, and pre- and post-study questionnaires, as well as semi-structured group interviews. The questionnaires mainly helped us to analyze the roles of the team members.

Recordings were made from four different angles so that the entire workspace was covered; a separate channel was reserved for sound. Altogether 21.5 hours of video data was collected. Our role as researchers was principally to observe the participants’ collaboration. However, since the workspace was part of our research environment we also had to help out the participants when they encountered problems with the system.

**Data analysis**

Two analytic techniques—interaction analysis (Jordan & Henderson 1995) and conversation analysis (Pomerantz & Fehr 1997)—influenced this analysis. The recorded materials were reviewed several times, sometimes collaboratively, and regularly made content logs and notes were kept. The notes covered a wide range, from the content monitored or manipulated on the displays to social interaction between the team members. The most interesting parts were transcribed, including information about time stamps for the beginning of transcripts, as well as the participants’ gestures, gaze, and manipulation of objects.

**Results**

**How the tools support the team members in contributing to the overall work**

The data show that the large displays supported the team in propagating ideas. The team members used the large shared displays when they were proposing and collectively refining ideas. They used them to make sketches and search for information on the Internet; in both cases their goal was to

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27 That is, the mammals in existence before the primates developed.

28 The teams were free to book the iLounge as much as they wanted during these two weeks (but not at the same time).
make information available to the others so that they could discuss it. While
they were producing a sketch, usually one team member would stand in front
of the large wall display, and the others would sit around the table. They
took turns being in charge of drawing the sketches and used several tools in
parallel: one participant could be using the touch functionality of one dis-
play, while another was using the keyboard and mouse to work on the same
document, and the third would be using the tools PointRight and iClipboard
to insert a piece of text; in combination these tasks would create a sketch.

**How the physical layout of the space impacted the propagation of ideas**
The two teams used the physical space differently. One team preferred to
work in the main working area all the time, while the other used the so-
called corner area for individual work a couple of times. The first team rec-
ognized the risk of not being able to be with the team. We have seen that
physical space matters when people are concerned with getting ideas into the
discussion immediately, but this does not preclude people from having con-
siderable influence in the joint group work. We have chosen to call this phe-
nomenon ‘backdoor creativity’ as a way to point out that, even in the physi-
cal sense, peripheral team members are contributing to their team’s overall
creative work.

**How the tools impacted the team members’ role assignments**
The use of tools seemed to impact the role assignment, and the participants’
own comments confirmed our observation. Their roles become more equal-
ized when they were working in an interactive space. We interpret this as
follows: the large wall displays, which give the team a shared view of the
common work, in combination with the tools that facilitate different kinds of
interactions, make it possible for everyone to contribute in whatever way
they preferred. Looking at the data it was obvious that some participants
preferred to work directly at the large display using pencils or their fingers to
draw and write, while others preferred to sit typing and inserting pictures, or
using a computer to look for information on the web. This could also be seen
as an indication.

**Paper II: Learning Conceptual Design: Activities with Electronic Whiteboards**

Paper II reports on the same study covered in Paper I. Here, however, the
focus is only on one of the team, the one with five members. It continues to
look at the use of tools, focusing primarily on the shared wall displays, in
particular the electronic whiteboards (i.e. the Notebook). The paper aims to
answer the following two questions: [1] How do the tools support the team members in contributing to the overall work? And, [2] how do the team members appropriate the tools so they can contribute?

Results

How the tools supported the team members in contributing to the overall work

The analysis showed that by making sketches on the electronic whiteboard the team members could enter the team’s collective memory and the history of its work process. In this way the tools supported the team work by making it possible for the team members to go back and create and re-create a shared view and shared understanding of their work. It also gave them a chance to re-negotiate and re-represent earlier proposals.

The tools in the interactive space supported the team members when they wanted to create sketches and storyboards by enabling them to work on the different displays in parallel. For instance they used one of the wall displays to search for pictures on the Internet and the other to make sketches.

How the team members appropriated the tools so they could contribute

At first, the team members acted as if they were slightly embarrassed about ‘going public’, that is, writing and drawing directly on the large displays on the wall in front of the others. When none of the team members wanted to draw, they used the other display next to it to search for pictures on the Internet; they then inserted those pictures into their document. In this way they were able to contribute without being inhibited by their sense of exposure to the others. Once they had appropriated the tools, they did not think about the appearance of the drawings and began to mix inserted pictures with drawings made by hand. Thus, we see that inserting pictures from the Internet helped them to overcome the fear of going public.

Paper III: To Share or Not to Share – Distributed Collaboration in Interactive Workspaces

Paper III focuses on geographically distributed collaboration in interactive spaces. The teams did not have an identical space but they did have a common setup that they used for their meetings, which created a shared space. This paper aims to answer the following three questions: [1] How do the tools support the team members in contributing to the overall work? [4] How does the participation mode (i.e. video and audio, or audio only) influence
the way contributions are made? And, [6] how do the tools impact team members’ role assignments?

Method

General description of data
We followed nine meetings of an international research network that involved about twenty team members, at ten laboratories spread out across Europe and North America. All the laboratories had access to so-called interactive spaces. The teams were not working on a common project but they regularly exchanged ideas and knowledge between the labs. Every month they had a geographically distributed meeting. The meetings were divided into two parts. During the first part, for which 45 minutes was reserved, all the labs were to be connected and technical issues were discussed. The second part, which lasted about an hour, was the research seminar, where network activities and research were presented and discussed.

During the meetings we followed, 4 to 7 teams were present at a given videoconference, and sometimes one or more teams were present in audio only; anywhere from 11 to 19 team members have participated in various meetings.

Data collection
Data were collected through participant observations and video recordings. In addition pre- and post-meeting questionnaires were handed out or emailed. The questionnaires mainly helped us to understand the team members’ personal objectives in attending the meetings.

The meetings were recorded at the LDC, at EDF R&D, which is one member of the network. The recordings were made on two to four fixed cameras; one channel also recorded sound. The cameras covered several angles in the meeting space: one camera for the shared media space, one for the display for the picture of the videoconference, and finally one or two for the local space. The data collection consists of about 18 hours of video recordings.

Data analysis
Three analytic techniques—interaction analysis (Jordan & Henderson 1995), conversation analysis (Pomerantz & Fehr 1997) and initiative-response analysis (Linell et al. 1988)—influenced the analysis. All the data was viewed several times, and content logs and notes were kept regularly. The notes covered a wide range, from the content monitored or manipulated on the displays to social interaction between the team members. The verbal

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29 LDC is also the organizing lab.
interaction was transcribed from the beginning to the end for five of the meetings (with regularly indicated time stamps). The most interesting parts were re-transcribed, adding detailed information, including the exact time stamps for beginnings and endings and manipulation of objects when it was needed to understand the interactional organization (cf. Suchman & Trigg 1991).

Results

How the tools supported the team members in contributing to the overall work

Two conditions made the meeting situation very complex: each team member could be connected to either video and audio or audio only, and each member had a complete view only of his or her own local situation. During the meetings they spent quite a bit of time creating a shared understanding of the situation. That is, they needed to understand who was participating, which technical resources (media space and instant messenger) the others could access, and whether or not everyone could hear and see adequately. All these factors hindered fluent communication between the team members.

Normally, they had few problems in using the shared media space, except for the restriction that only one person could be active at a time. This led to problems when several people wanted to contribute simultaneously, so they had to organize a process for taking turns. This experience revealed a gap between the individual and the system and therefore also between the team members. They did overcome some of these limitations in the system by verbally articulating the action they were taking on the equipment.

How the participation mode influenced the way contributions were made

Because of the problems in having an overview of the situation, the chair introduced the team members present on the audio-only channel. This step was important because it allowed both those present on audio only and those on video and audio to know who was only on audio. But it emerged that, even when someone had been introduced at the start of the meeting, others might still forget about them. In addition, the communication space seemed to be limited: when many wanted to participate in the communicative activity, it became harder to make successful initiatives. It was most difficult for those participating on audio only to contribute to the discussions, but this did not mean that by default it was more difficult to make major contributions.

30 The meetings that were not transcribed either contained many very long monologues or suffered from technical problems.
How the tools impacted the team members’ role assignments
In the co-located setting we saw indications that the workspace helped to equalize the roles between the team members. In the geographically distributed setting, in contrast, the team members’ roles became accentuated. Their initiatives and responses were received either more weakly or more strongly than they would have been in a face-to-face situation. This is probably related to the role or the status that each team member already had in the network and to the fact that the communication space was limited.

Paper IV: Social Conventions and Issues of Space for Distributed Collaboration
Paper IV is based on the same study presented in Paper III. It aims to answer the following three questions: [5] What kind of social conventions do the teams create for their collaborative activities? [4] How does the participation mode influence the way contributions are made? And, [7] how does a “distributed” location influence the role one can take in the collaboration? The latter two issues were examined by looking at a situation when most of the network members were located in the same physical location and by analyzing how decisions were made.

Results

The kind of social conventions the teams created for their collaborative activities
The team members developed several conventions to handle their meeting situation. One convention (also reported in Paper III) was that the chair introduced the team members early in the meeting, since it was difficult for them to have an overview of who was participating and on which communication channel. Also, the chair tended to re-check the presence of team members later in the meetings.

Two conventions arose to minimize disturbances during the meetings: using an instant messenger made it possible for them to communicate and solve connection problems silently during the meetings, and turning off the microphone when one was not engaged in discussion reduced echo and background noise. The latter convention led to the side effect of quicker decision making, because local team members could engage in parallel discussions.
How the participation mode influenced the way contributions were made

After the discovery that turning off the microphone may lead to quicker decision making, decision making was investigated in a meeting where all but two teams were located in the same place; this was a contrast to the typical meeting situation in which all the laboratories were participating from a distance. The team had to make a decision that all the team members had to agree on. In this situation the observation focused on how the decision was first made among the team members who were co-located, and then by those teams on the two distributed teams. The distance between the physically co-located participants and the distributed ones was probably also influenced by the fact that the co-located people talked more intensively with each other at two particular moments. To include the distributed team members in the decision-making process, the chair made a strong initiative, turning directly to them.

How a “distributed” location influenced the role one could take in the collaboration

To understand what it means to be “distributed” the focus then shifted to the meeting that had the most participants gathered in the same place (the same meeting as analyzed for the previous question). Two characteristics of the distributed team members and their situation were identified. The first phenomenon is implicit excluding: although no one intended to exclude the distributed participants from the co-located team members it happened anyway. Sometimes it happened because the co-located participants shared something that was hard or impossible to transfer over the video link. That finding leads to a suggestion: the situation is fairer when all the teams are distributed, because that reduces the risk of anyone being implicitly excluded. On the other hand, in the rest of the corpus the risk of being excluded was also noticeable, especially when someone was participating on audio only. One way to overcome these limitations of the system was for the chair to work actively to include the others. This leads to the second phenomenon: explicit including. This is the observation that it is easier for someone to make a successful turn if someone else has already made a strong initiative to include them in the discussion. The related suggestion is that chairs, or other participants, make an explicit effort to include others.


Paper V investigates how the physical qualities of the space impact the collaborative activities (i.e. the third research issue). This analysis is based on
the two studies presented in papers I through IV. The aim here is to identify some of the issues of space that seem to play an important role when team members are collaborating.

The focus is on the physical space as a social space. These two aspects are closely intertwined: the experience and material qualities of the physical space influence the way we act. The theoretical framework (see Chapter 2) is based on ‘proxemics’ (Hall 1966), ‘territoriality’ (Sack 1986) and the work of Goffman (1959).

Results

The first study revealed the need to move between different distances (Hall 1966) and to have access to a back region in addition to the front region (Goffman 1959). Team members expressed the first need by choosing to work in the “corner” area. To some extent the tools supported the second need: the persons writing directly on the large displays clearly seemed comfortable with a central or focal position, visible to the other team members, while others preferred to have a role that was less on display. But the members who were less on display still had the potential to impact the others, by using mouse and keyboard, or sending information from the laptop. This shows how it was possible to contribute to the common work in both the focal and peripheral positions.

In the second study it was observed how the physical space impacts the actors, in line with the statement by Benwell and Stokoe (2006) that “spaces make people”. In the distributed setting the team members were involved in the ongoing construction of a common (work-) space (cf. Cresswell, 2004; Massey 1994, 2005). That is, the participants had to clarify who was attending in which mode (audio and video, or audio only) both before and during the meetings; this need became clear when some participants were implicitly excluded, but was met to some extent as the chair explicitly included them in the discussion.

The ability to move in and out of spaces, physically as well as socially, was shown to be an important aspect when collaborating. People need to be able both to create and have access to private spaces. In the co-located setting it became clear that the way in and out worked quite well for the team that used this possibility. The other team did not use this possibility, hesitating to sacrifice the sense of team work; this indicates that the transition between the private and the public spaces was not visible (or transparent) enough.

In the distributed setting the idea of going in and out of spaces was apparently much more complicated. The likely reason is that the team members cannot initially choose which mode they will be participating in, and that the only ones visible to all the others are those in video mode. However, team members could communicate in various ways: with everyone in the common
discussion, with local team members, or with individual distributed team
members. But these co-existing networks did not offer any transitions in and
out for the others (except for the common discussion).

Another important aspect that became apparent in the studies is that the
physical space (the material resources) plays a role in determining the roles
and distributing them between the participants. That is, the team members’
roles are not necessarily static or only socially constructed; the physical
qualities of the space serve another part of this process of team members
taking on different roles.
This thesis aimed to understand collaborative activities in interactive spaces; that is, technology-enhanced environments that are characterized by a blend of shared and private displays, and software tools that facilitate fluent sharing of information between the displays. The subtitle *The Construction of a Collaborative Reality* points out that each team must construct its own collaborative efforts. This would also be true of collaboration in any other kind of space. In the present study the construction of a collaborative reality has been investigated by analyzing the ways collaborating team members are allowed to contribute to the overall work and how they handled roles and functions when collaborating. During this work a third issue emerged: how the physical qualities of space impact the collaborative activities. This final chapter addresses the results of this work in light of the research issues. It also considers reflections on the methodology and suggests some future research.

**Contributing to teamwork**

The first research issue was how the team members were allowed to contribute to the overall work when collaborating in interactive spaces. In the first study we saw how, over two weeks, the two teams focused on making the conceptual design of a multimedia guide in the iLounge. For their kind of activities (brainstorming, searching for information, sketching and making storyboards) the interactive space was helpful. The results showed that the team members in the co-located setting had various options for contributing to the overall work, and used them. They used the shared wall displays to search for, show, and create information and documents. The touch-sensitive wall displays enabled them to interact directly using their fingers or a pencil to write, or using the ordinary mouse and keyboard. They could also send information between the displays (computers) using the specific software tools available (i.e. Tipple, Multibrowse, PointRight, and iClipboard). The ability to make sketches and storyboards on an electronic whiteboard enabled them to re-represent and re-negotiate their earlier proposals. In addition, the physical layout of the space itself made it possible to divide up the work. Although one team did not take advantage of this option, the analysis of the other team’s work showed that while working separately made it more
difficult for members to get their ideas into the discussion immediately, it was still possible to have considerable influence on the overall work.

In the second study the goal of the collaboration was less clear, or more open-ended. The team members had a range of objectives for attending the meetings, which could be summarized as “sharing knowledge”; that is, they wanted to share and distribute knowledge and experiences within the network. The shared media space was mainly used for showing presentations during meetings, and less for producing or creating anything that would have forced them to interact and use the tools simultaneously. Their collaboration was mainly verbal, using spoken language. However, when they used the shared media space they had to work out how to take turns, because the technology limited the number who could interact simultaneously. Someone had to take on the role of organizing the turns. Though verbal interaction let them overcome this limitation in the system, some solution should be designed into the system; one possibility is a queuing function to overcome the problem of sequentiality. It would also be helpful if the media space could indicate that someone is active (and preferably who that is), this would at least reduce the confusion on that element of the work.

The situation was complex for the team members in the distributed setting, primarily because the use of both video- and audio conferences made it difficult for them to keep constant track of who was participating. This problem is probably also related to the fact that several teams (up to 10) would participate in any given meeting. The chair tried to introduce, and reintroduce, team members at the meetings, but they always faced the risk of being excluded from the discussion. In addition, the communication space seemed to be limited: when many wanted to participate in the communicative activity, it became harder to make successful initiatives. Team members who were on audio only had the hardest time entering the discussion, but they were still able to make major contributions, especially if someone else had already made an initiative to include them in the discussion. At one meeting, where most teams were co-located, it was clear that the members of the two distributed teams had a hard time contributing to the ongoing discussions, and the two decisions were first made by the co-located team members and then by the distributed ones. Two interventions would help this situation. First, an image or a photo of all the participating team members posted on the media space would make it easier for each participant to be aware of the others; second it would help to tag the image or photo to indicate who is participating on video and audio, and on audio only.

Naturally it is much easier for team members to register their co-participants’ actions when they are in the same physical space, compared to being “distributed”. As the data in the second study showed, this difference between members often caused problems when they tried to take turns, especially for those who were not already part of the communicative activities. This is seldom a problem in face-to-face interaction. Obviously this is re-
lated to the fact that the contextual information is reduced, so being visible seems to help the team members to be aware of the others and to see what they are intending or trying to do. In the distributed setting turn-taking was mainly a problem for those taking part in the communicative activities because the nature of the meetings was verbal discussion. But the problem was also apparent when several team members wanted to type into a document in the shared media space; here the situation was equally difficult for the participants on video and on audio-only.

Handling roles and functions

The second research issue concerned how roles and functions were handled during the collaborative activities. The team members in the co-located study had no predefined roles when they began working as a team. But as the students said themselves, normally team members take on different roles while collaborating. In this work they meant that their roles became equalized. This experience may be connected to the fact that they all felt that they had a chance to express their opinions and said that the workload was equal between them. The analysis of their work showed that their roles were emergent when they collaborated and that the roles shifted between them. We interpreted this as indicating that the tools, especially the touch-sensitive wall displays and the shared view they provide, gave the team members an overview of the work and allowed them to interact in different ways. This set of conditions let each of them find a preferred way to contribute to the work. It also made them feel that there was no particular leader in the group and that they all could have an impact on the work.

In the second study, the team members had different roles and functions at the beginning. The members of the labs were professors, senior researchers, doctoral students, undergraduate students, and technicians. An obvious hierarchy between the team members already existed. Also, on a team level, some teams had cooperated before or knew each other better for other reasons. Even if they never expressed those roles explicitly, this underlying structure existed, potentially influencing the teams and team members in their collaborative work. As seen in the transcripts of the meetings, the chair played a prominent role.\(^{31}\) He introduced teams and team members to each other early on in the meetings, and he had to confirm and re-confirm each person’s presence. Compared to first study where the team members’ roles became more equalized, the roles were accentuated in the distributed setting, as the initiatives and responses were received either more weakly or more

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\(^{31}\) The chair was the head of the lab that had initiated and continued to organize the meetings. His lab had contact with the other teams before the meetings to determine who would be attending; it also helped out technically when teams had problems connecting, etc.
The data showed that it was hard to enter the discussion if one was not already part of it and those participating on audio only had the hardest time. Those who were not part of the discussion and were also at a “distributed” location experienced another effect: some teams were implicitly excluded, although no one intended that to happen. Again, the chair made an explicit effort to include participants, but this remained a problem. Together, these data indicate that the setup involving several communication channels made it difficult for anyone to have an overview of the entire situation, and the chair had an important role in managing the team members’ situations.

The two situations studied are very different in several respects: the conditions, the teams’ shared space for collaborating, the task, and the composition of people. The aim of this study is not to compare the two situations, but it is possible to reflect on differences and similarities and learn from the two. It is natural to have different roles and functions in teamwork; normally one is asked to do the things one is good at. The role that was most clearly needed in this work was the chair during the distributed meetings. His role was not just to oversee the agenda, but also to actively include participants, especially those on audio-only who were literally invisible to the others.

**Issues of space for collaboration**

The third research issue concerned the physical qualities of space and how they impacted the collaborative activities. Paper V presented a number of related issues of space that have an impact on collaboration; they can be summarized as mobility, visibility and role assignment. More precisely, when the team members need to able to move in and out of public and private spaces during collaboration, this movement must be visible to the others; finally, the physical space—not only the social relationship between the team members—is part of the process of role-making and role-taking.

In both the co-located and distributed settings, several spaces co-existed when the team members were collaborating. In the study on co-located collaboration we saw the team members working on private and shared displays in parallel; this created a private sphere in the shared space. Working in the “corner area” gave members an opportunity to work for a moment in the periphery. The study on distributed collaboration also included a private sphere, but it was not deliberately chosen. In the group-to-group collaboration, teams were connected into the shared space and formed private islands. For team members, it was not always easy to move from a peripheral to a central role in the activities. Despite the shortcomings of this setup we saw that the participants in the distributed setting were able to communicate and interact with each other in several ways: with the team members in the common discussion, with the co-located team members, and with individual
distributed team members through the instant messenger. As a result of the
group-to-group collaboration, several different networks co-existed (cf.
Mark et al. 2003).

These observations show how team members create *spaces within
spaces*, that is, they create their own spaces in the common space. This leads
to the conclusion that collaborative work environments must be designed in
ways that make it possible to move in and out of spaces. This is in line with
the work of Rogers and Rodden (2003); to help lessen actors’ fear of going
public (cf. Paper II), they suggest designing ‘transitions’ between public and
private spaces as well as ‘thresholds’ between focal and peripheral activities.
An important finding in the present work is that the transition should be visi-
table to the other team members. As seen in the first study, one team took the
opportunity to use the corner area, while the other team did not, hesitant to
sacrifice their sense of the team. The results showed, however that this fear
was not justified: members of the first team, who did use the corner area,
were still able to influence the team’s overall work. This observation leads to
a suggestion: it might have been helpful if the transition between the two
working areas (i.e. the areas for focal vs. peripheral and public vs. private
work) were even more visible, so that all the participants would feel that it
was possible to divide up the work in an interactive space. Maybe if the two
working areas had been physically closer the members would not have felt
concerned about “sacrificing” the team. The study also showed that the tools
to some extent supported Rogers and Rodden’s (2003) idea of thresholds:
some team members did not have any concerns writing directly on the large
displays, but for those who preferred to have a role that involved less dis-
play, they had the possibility of impacting the others through using the
mouse and keyboard, or sending information from their own laptop.

**Reflections on methodology**

Studying and analyzing human interaction is a complex task. In this thesis
the main technique for doing that has been in-depth investigations of video
recordings. Interaction analysis has been my starting point in approaching
the videotapes, but from the beginning it was complemented with other ones,
such as conversation analysis. Over time I adjusted and developed my way
of doing the micro-level analysis and realized that I preferred ethnomethod-
ology. Though this work is not fully grounded in ethnomethodology, it has
influenced my way of thinking about the analyses and the actors’ activities
in the studies.

This study diverged from ethnomethodology in one important way. Though ethnomethodologists discourage using categories unless they have
been shown to be relevant (Koschmann et al. 2007), I did use them to some
extent. In the analyses of the second study (paper III and IV) I used the ab-
abstract categories of initiatives and responses, focusing on how new episodes are introduced. I also used more precise categories in paper III, such as information request, information delivery, action request, action verbalization, etc., to categorize each turn. Those categories were created in a somewhat ad hoc way. In paper IV I tried to create a system of categories in accordance with the work of Baker et al. (2003). In retrospect I think that the latter categories did not improve the analysis. On the other hand, the abstract categories of initiative-response analysis were helpful because they focused on the turn. In face-to-face interactions turn-taking occurs naturally, but in the distributed setting, which in this study was very complex due to the multi-channel setup, it suddenly became a problem when communicating and collaborating. In analyzing this situation the initiative-response analysis helped me to understand how the communicative activity proceeded.

The first study was done in the context of the university, where researchers can design their studies quite freely and can generally find students who are willing to be participants. For our purposes, however, we wanted to set up a study that was meaningful both for us as researchers and for the participants, and one way to do that was to take part in an already existing course. In the second study the situation was different. The study was carried out at EDF R&D, a very large company (over 160,000 employees as of 2005). Because I did not speak French when I arrived and because I was at a company rather than a university setting, I had limited possibilities in choosing which group to follow and how to set up a study. EDF usually used their interactive space for internal, geographically-distributed collaboration (i.e. videoconferences). In an ideal situation I would have liked to have studied the collaboration (at a distance or co-located) of a team whose work required the members to interact more and manipulate shared documents; that is, it would have been interesting to observe more than (mainly) verbal interaction.

**Future work**

Several future efforts could serve as continuations of this study. Because interactive spaces continue to be the focus of research and development the first suggestion would be to study teams working (either at a distance or co-located) in an interactive space when the system (setup) is stable. Another suggestion would be to study teams that have longer access to the space, spending more hours and over a longer time span. This would enable the team members to more truly make the tools and the setting their own. This would also lead to a better understanding of what kinds of tasks and activities the interactive spaces support.

When it comes to geographically distributed collaboration it would be recommended to study teams whose task is more goal-oriented, requiring
them to make contributions, interact, and manipulate shared documents. This would lead to better understanding of how the tools in the interactive space support collaborative activities at a distance. If the system were similar to the one presented in this thesis (i.e. using both video and audio, and audio-only channels) it would be useful to try out an application that shows a photo or image of those attending the meeting and tagging those on audio-only, as well as having a “queuing” function for regulating the problems of sequencing.

For both types of collaboration—co-located and at a distance—it would be interesting to go further and study team members’ roles when collaborating to better understand the relationship between the physical space, the task, the team, and the roles the members take on. In this case it would be important once again to choose a task where the team has a clear goal to achieve, requiring them to work on and manipulate shared documents. It would also be useful to interview the team members to learn about their personal experiences of their roles and the teamwork.

The aim of this thesis has been to understand collaborative activities in interactive spaces in terms of how team members are allowed to contribute to the overall work and what influence the physical qualities of space have on the collaboration. The present study showed that the physical qualities of space—the architecture, layout of space, the tools, the material qualities of the tools, etc.—influenced how the team members were allowed to contribute and how they distributed roles. It also showed that the physical space and the social space were overlapping and intertwined; they appeared as spaces within spaces. The members of the teams were also in a concrete sense constructing spaces within spaces: they created their own spaces in the common space and they often made transitions between shared and private, focal and peripheral work. These transitions were, however, not unproblematic for the team members, because they were not always visible enough. This issue must be considered in any future effort to design spaces for collaboration.


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