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and Communication**

Social Awareness Support for Cooperation

Design Experience and Theoretical Models

Ovidiu Sandor

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School of Computer Science and Communication
Royal Institute of Technology
Stockholm, Sweden

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ovidiu.sandor@business-centre.ro

Abstract

This thesis addresses the research question of how *social awareness* support in computer systems for groups and communities can be designed in a successful way. While the field of human-computer interaction has been working with similar questions for more than 20 years, many aspects of people's cooperation and the way those should be considered in system design still need further consideration and research.

The thesis presents a number of projects where systems for cooperation have been designed for different settings and different kinds of use with a particular interest in *social awareness*. Drawing from the experiences of the different projects, design sensitivities around awareness, as a central prerequisite for collaboration, are suggested.

Another contribution of the thesis is the presentation of a theoretical model for awareness, called *Aether*, introduced by us a number of years ago. We will discuss the theoretical implications of the model as well as a number of applications of it based on our own work as well as based on the work of other researchers who used *Aether*, by this providing confirmation of our model.

Based on the findings around awareness, the thesis argues for a 'translucent' approach to the issue of socio-technical balance that one has to consider in the design process. Instead of trying to understand and model human behaviour or the social organization of cooperation, in order to 'code' them into the computer system, this approach advocates for systems that mediate information in a 'translucent' way so that people can retain the control of the organization of cooperation in their given context.

By using a 'reflective practitioner' approach, the thesis discusses how people-centred methods have been used throughout these projects and looks into how awareness could be considered by using these methods. The focus of this investigation is twofold: on one hand to understand how the used methods have influenced our discussion about awareness

and on the other hand it aims to address the practitioners of the field by questioning some of the common beliefs in the field.

By investigating social awareness support in collaborative systems, the thesis contributes to theoretical arguments in the field of human-computer interaction, and the area of CSCW in particular, while at the same time it provides the interaction design practitioner with a number of considerations for practical use.

Keywords

HCI, CSCW, social awareness, user-centred design, Spatial Model, Aether Model, communities, knowledge.

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To the memory of my father

*I can only imagine
how proud he would have been
to see me arriving here*

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1. Introduction

1.1. Awareness

In the field of Computer Supported Cooperative Work (CSCW), as a relevant part of the HCI research agenda, a strong interest in the issue of *awareness* emerged from the beginning. In designing computer systems for cooperation, researchers noticed very early on that their expectations in terms of results did not materialise (Grudin 1988). Even if their systems provided users with good communication channels, be it sound, video or text, still, interaction between the different actors was limited. They started looking at the cause of this and soon realized that notions used up to that moment, like ‘communication’ or ‘workflow’ could not fully encompass the ways in which cooperation really works. Early workplace studies based on ethnographically inspired methods (e.g. Heath and Luff 1992) pointed out that coordination and integration of activities happened in ‘seamless’, often non-verbal, non-explicit ways. These ways of projecting and monitoring surrounding information for use in the collaborative process were labelled as ‘awareness’ (Dourish and Bellotti 1992).

Soon after realising that computer systems for cooperation might fail precisely because of the lack of support for this information exchange, awareness became one of the central themes of CSCW research work. While most researchers agree on its importance, finding a clear definition of awareness has not materialised (Schmidt 2002). Though awareness is an everyday word, dictionary definitions do not help us to place this concept in the CSCW research.

A number of earlier researchers attempted a definition that would be useful for this field. One such often mentioned definition (Rodden 1996), suggests that awareness is “knowing what is going on... understanding the activity of others... information that provides context for own activity”. Dourish and Bly (1992) propose that awareness is “knowing who is around, what activities are occurring, who is talking

with whom” while Dourish and Bellotti (1992) define it as "understanding the activity of others as a context of your own activity".

We find it useful to also identify what awareness *is not*, as this will delimit the scope of the concept and of our interest, in this way complementing the definition of awareness:

- awareness *is not only* feedback; the major difference between the two concepts relates to the people involved; while feedback means some sort of information that confirms to a person the effects of an action taken by the same person, awareness refers to information that one person has about another person or artefact; as such, good collaborative systems need to provide both adequate feedback and adequate awareness;
- awareness *is not only* communication; while awareness involves exchanging information, it is not the same as communication; the fact that a system provides communication between different people does not automatically imply that proper awareness information is also exchanged; communication channels can be surely used to convey awareness information but from a conceptual point of view it is important to keep in mind the distinction;
- awareness *is not only* coordination; while awareness is often used for coordination, it offers a richer understanding of the social situation than just the coordination aspects.

In order to complete the description of what awareness *is* it is useful to list a number of characteristics of real-life, face-to-face awareness. These characteristics will be used in the different chapters as reference points in discussing the computer mediated awareness support solutions suggested here or in related research. In the final chapter we will come back to these characteristics and we will suggest how these could be used as considerations in approaching social awareness issues in design projects. While a number of studies, especially ethnographic ones, have identified various aspects of face-to-face awareness, we list here the most relevant ones for this thesis:

- *Real-life awareness information* sent out by people *is a by-product of human activity*, requiring no major additional effort.
- *Humans have developed refined ways of controlling* the awareness information that they 'send out'.

- *Real-life awareness requires regular monitoring.* This means people are constantly on the lookout for clues and indications of what is going on with other people around them.
- *Real-life awareness information collecting is a peripheral activity.* Under normal circumstances people are focused on certain tasks but have developed in time the skill of 'being aware' of what is going on around them. This activity is done in a peripheral way in relation to the main task. When needed, focus is shifted towards the awareness information of interest, but mostly all the information collecting happens in the background of our attention.
- *Humans have developed advanced skills in selecting relevant information and inferring awareness information from available sensed facts.*
- *Real-life awareness information is collected for unknown (but anticipated) future use.*
- *Real-life awareness is bound in space.* In our physical world, we rely on our senses in order to gather information about our surroundings. In the case of face-to-face cooperation we use hearing, seeing and touching in order to monitor not only the environment but also the activities of the other people, as noted by the ethnographic studies already cited. But the senses we normally use are physically constrained to a very limited space around our bodies. We will not know whatever happens outside our 'sense field', at least not through direct perception.
- *Real-life awareness is bound in time.* Our natural senses work in a very limited way if one considers the time element. We are able to sense events that happen only in the present. We cannot hear sounds that were generated yesterday, nor can we see who has been in the same room last month. Even with this limitation we have learned to read the traces of the past in the present environment and we are very often able to reconstruct certain elements of the past. We use memory to store and retrieve this information, but in terms of sensing we are bound to the given moment.

Besides these characteristics, real physical space has another specific affordance, that of *unplanned encounters*, which means the possibility to 'bump into' someone else or into the traces of someone else. Such encounters have been identified as very relevant events that contribute to

improved social interaction, to informal information exchange and to possible future collaboration.

In computer systems, when considering awareness issues for collaboration, designers try to either replicate these characteristics, where needed, or attempt to use the flexibility offered by Information Technology to improve on these characteristics. As we shall see, these considerations are linked to the given setting and the given goal of the application under consideration.

While describing some of the important characteristics of real-life, though face-to-face awareness offers us a better understanding of what awareness is, it still does not provide the complete answer. Other authors, understanding the difficulty of a general definition, sought to limit the scope of the concept to a certain aspect of it. As such we have definitions of *general* awareness, *social* awareness (Tollmar et al. 1996), *peripheral* awareness (Moran and Andersson 1990), *background* awareness, *passive* awareness, *mutual* awareness and *workspace* awareness (Gutwin and Greenberg 2002).

Workspace Awareness

One of the early directions taken by awareness studies was that of *workspace awareness*. Based on and influenced by ethnographic studies of workspaces, researchers and designers have attempted to 'capture' the elusive awareness and to 'translate' it onto the screen of the computer system. That became the new *shared workspace*.

While no agreement has been reached on what exactly workspace awareness is, there is more clarity on what this information is used for. Gutwin and Greenberg (2002) found the following elements of collaboration that are influenced by the available awareness information.

MANAGEMENT OF COUPLING is the constant "moving between concurrent, but more or less independent, work... to very tightly focused group consideration of single items." These "...movements are opportunistic and unpredictable and rely on the awareness of the state of the rest of the group". The person uses this awareness information to manage this elaborate "dance".

SIMPLIFICATION OF COMMUNICATION. Awareness information creates a strong common context for communication that allows the use of symbols, signals and body movement instead of verbal communication.

COORDINATION OF ACTIONS. Awareness information is essential in helping people make things happen at the right time and in the right order. While obviously explicit communication allows for coordination, in daily situations we instead tend to use awareness information that we gather continuously. This allows for subtle, less explicit coordination. Key in such situations are body positions or body movements as well as the state of shared artefacts. Awareness information is so important for this coordination that a number of studies (e.g. Heath and Luff 1992) have observed communication breakdowns or misunderstandings because of bad or lacking awareness.

ANTICIPATION. Awareness of others and of the shared space allows for anticipation. This is naturally based on our expectations of the given situation and on predictions that we will make based on the available information. This enables pre-emptive actions and forward-looking coordination.

ASSISTANCE. One often needs to ask for assistance from others during cooperation. While this is common, it is normally not done through explicit communication. Indirect cues are used to ask or to offer assistance. These signs are not part of the main communication channel but are picked from the awareness information. A raised head or the awareness that your colleague is not typing when she normally would, might indicate the need for assistance.

While the concept of awareness and the focus of the investigations around it have evolved from desktop awareness, as addressed by Gutwin and Greenberg (2002), the framework they propose raises a number of valid questions that can be also asked when the concept of awareness is extended beyond the desktop.

Social awareness

The focus on workspace awareness is characteristic for earlier studies on cooperation and communication. We can notice a shift from systems addressing cooperation in small groups to a broader context of collaboration. This extended context includes more social aspects. Slowly, a number of new definitions of awareness appeared where the social context of our interactions plays a key role. This shift of focus was natural as a number of computer-based cooperation systems were noticed to fail (Grudin 1988), not because of wrong technology or badly

designed interfaces but because of social rules and behaviour outside the scope of the computer system.

Once it became clear that awareness was also to be found outside the desktop, the focus of a number of researchers became the concept of *social awareness*. We have defined it (Tollmar et al. 1996) as being "... awareness about the social situation of the members [of a group], i.e. awareness about what they are doing, if they are talking to someone, if they can be disturbed etc.". Along the same lines, Schmidt (2002) considers that social awareness "... is thus conceived of awareness of the social context and is seen as something that engenders informal interactions and a shared culture". In our paper (Tollmar et al. 1996), we also include within the realm of social awareness the "... information about the knowledge [of others]... as it will increase the potential of collaboration within a group."

We believe this type of awareness is also central in less formal work settings, like for example in communities of practice (Lave and Wenger 1991), as we will see in some of the projects described in this thesis. In such settings, there is no formal structure of power, skills or knowledge. It is only the intimate understanding of each member's role in the community, meaning, having the 'social awareness', which makes the community function properly.

Social awareness has become increasingly important in CSCW research and in HCI in general, as it is seen as a relevant factor in *work*, not in the traditional form of it but in the rather elusive, unstructured, informal part of it. Especially in organizations where information is seen as the major 'product', social awareness is considered key to developing the kind of social context in which this information flows easily and naturally among people. High social awareness improves social interaction and thereby favours spontaneous discussions and meetings or, generally, enhances social interaction. These in turn encourage people to help each other, to exchange ideas and practices and finally lead to knowledge transfer and knowledge building.

These social concerns are also relevant for the projects presented in this thesis. Some of these projects address communities, which have a strong social component that needs to be taken into account in system design. Not only is the online, direct interaction with the system of importance, but also the social interplay that takes place outside the digital tools used by such communities.

Improved social awareness will generally mean a better context for *improved social interaction*. This is because social awareness favours spontaneous interaction and encourages helping each other. All this leads to better knowledge transfer, be it in formal groups or in less formal communities of practice, as we will argue later on.

But social awareness and its benefits are strongly constrained by space and time. For example, Groth (2004) quotes a manager saying "... we had two departments that had a hard time cooperating. The problem seemed to be that one group was not aware of what the other one was doing. We moved them in offices close to each other and the problem disappeared."

Groups and Communities as Settings

Some of our projects will consider the role of interactive systems in providing support for social awareness in communities of practice, as defined and described by Lave and Wenger (1991).

The word 'community' comes from the Latin *munus* (gift) and *cum* (together). It was first coined in sociology as a contrast definition to (modern) society: *Gemeinschaft* vs. *Gesellschaft*, in the German language of the influential school of sociology around 1900 (Tönnies 1912). This school used the term (*Gemeinschaft*) to define small groups of people, normally in some remote part of the world, with little social organization. This was put in contrast with the modern society of those days (*Gesellschaft*).

While no clear definition is at hand, researchers have agreed on a list of implied criteria that one would normally associate with a community. Based on Pargman (2000), who is inspired by a number of previous researchers, the presence of all the following characteristics is required in order for some group of people to be considered a community: relationship, membership, time horizon, shared values, commitment and collective accomplishments.

As already discussed, work has been one of the most important focuses of HCI. Still, while older CSCW was looking at clearly defined organizations and workplaces, later the research agenda moved towards a broader definition of what work means.

This is especially true when it comes to information-intensive types of work, or what we can call knowledge-based work. For such activities, be

it within a given organization or across similar organizations, knowledge transfer and learning have been early targets of CSCW research. Initial efforts were trying to use IT for capturing and storing 'knowledge'. This has led to a number of database systems, of a simpler or more advanced nature (see for example expert systems of the 80's).

More recent approaches better understand the social nature of knowledge and have suggested totally different ways in which to approach technology design intended for organizational learning and knowledge transfer. For example, Brown and Duguid (1991, 2000) have long been concerned with the issue of "capturing knowledge without killing it". They build on two major sources: the investigation of knowledge-practice by Orr (1987) and the practice-based theory of Lave and Wenger (1991). They also start from the assumption that Process (the way things are organized) and Practice (the way things are done) are very different things. Brown and Duguid (1991) argue that the structures devised to follow the organization processes (so-called 'canonical' structures) will not be suitable for spreading of knowledge. Instead, the organisation should see itself as a "community-of communities, acknowledging the ... many non-canonical communities in its midst".

Suggested Approaches to Awareness

Over time a number of approaches have been used to improve workspace and social awareness and the projects described in this thesis are also examples of some of these approaches. These approaches can be grouped into what we will call 'awareness genres'.

While the term 'genre' in HCI has been used in various ways, for example by Cerratto and Lantz (2002), we will use it throughout the thesis in a meaning similar to that known in art and culture and as also used previously in HCI by, for example, Walldius (1998). For us, *'awareness genre' will be the term for any category of awareness support solutions based on some loose set of common technological and functional criteria.*

We will briefly present the relevant solutions suggested by previous research and, later on, in the final chapter, we will come back to these genres in order to discuss how the different approaches have worked and the way they address the questions and issues that are our focus.

While with any new technology new endeavours are being pursued for finding better and better solutions, still most systems, regardless of the current technology, will probably fall under one of the following types.

MEDIA SPACES. One of the early kinds of approaches was to use media-rich communication channels to improve awareness. The assumption here is that low bandwidth in communication channels lead to awareness information missing in the communication. If that would be the case, then a media-rich channel (e.g. video and/or audio) would also ‘carry along’ the natural awareness information together with the more explicit communication. Furthermore, this would come at no extra cost as the awareness information would be ‘collected’ without effort for the users and the ‘displaying’ of it would be made in a natural form to the user. Monitoring this kind of information would be nothing more than a real-life variant for the user.

Media-spaces were tested in a number of systems like: Piazza (Isaacs et al. 1996), Portholes (Dourish and Bly 1992), Cruiser (Cool et al. 1992), videocafé (Tollmar et al. 2001) and the K project (Lenman et al. 2002). These systems used either webcams that would grab video and broadcast it to the other members of a (rather limited) group, where this video would be projected onto the computer screens, or would grab video from different spaces (offices, corridors, open spaces, etc.) and would feed this video to a big screen projection located in some other public space (corridors, lobbies, etc.).

MESSAGING SYSTEMS. A parallel approach was that of awareness systems based on messaging. In these cases the assumption is that awareness information can be explicitly sent in low-bandwidth form, like text, either by some sort of automatic mechanism or by having the user broadcast small text messages to each other.

Such systems, suggested by earlier research, include @work (Tollmar et al. 1996) and Elvin (Fitzpatrick et al. 2002). Later on, this kind of solutions reached a commercial form with the breakthrough of ICQ, a small instant messaging system developed by the company Mirabilis, in 1998, and exploded in the 2000s with the broad use of Microsoft Messenger, etc. This type of application is well-spread and still used nowadays, having different forms and functions but keeping the same fundamental concept at their core (see for example Nardi et al. 2000).

SHARED VR ENVIRONMENTS. As technology evolved and allowed for more advanced 3D virtual reality (VR) systems, a number of research projects involved using such 3D shared virtual environments for improving communication and social awareness in geographically distributed groups. Early and very widespread systems for such communication

were DIVE (Fahlén et al. 1993) and MASSIVE (Greenhalgh and Benford 1996).

The assumption here is that by recreating on the computer the world around us, this would provide users with the same interaction that they are used to in real life. Moving around the space, seeing and hearing, using the body, in this case the avatar, are natural interactions and should form the basis for social interaction. In relation to awareness, of relevance is the Spatial Model of interaction suggested by Benford and Fahlén (1993) and by Rodden (1996), a model we will extend in this thesis with the introduction of the Aether model.

AWARENESS MODULES. In these cases awareness is not the primary function of the respective application but rather a supporting function of it. As the main task at hand is often well defined in these kinds of applications (shared file systems, shared editors, etc.), awareness support can be very specific for the task at hand. In most cases, shared-workspace awareness is provided, while in some systems social awareness is also delivered to a degree. For example, systems like bcsw (Klößner et al. 1999).

PHYSICAL INTERFACES. Recent visions like ubiquitous computing (Weiser 1991) as well as technical developments have led to systems where physical interaction is a central theme. These kinds of new techniques have also been recently used in relation to collecting/displaying awareness information. As technology now allows for cheap, energy efficient sensors with decent communication capabilities, it is envisioned that such solutions can be useful for capturing awareness information in a simple way. A number of projects are looking into providing awareness and predicting availability information based on the data collected by these types of sensors (Fogarty et al. 2005).

1.2. Research Questions

The thesis is concerned with the overall theme of *social awareness* in the context of *designing computer support for collaboration*. More specifically, a number of research questions are addressed.

In discussing the concept of awareness a number of issues must be considered. A framework that approaches these issues in a structured way is the one suggested by Gutwin and Greenberg (2002). While the focus of their endeavour seems limited to desktop awareness, the

framework does provide a coherent set of questions that need to be raised when designing systems for cooperation. According to Gutwin and Greenberg, there are three major concerns in the design of awareness features in systems that support cooperation:

- What kind of information do people keep track of in shared workspaces?
- How do people gather this information?
- How do people use workspace information in collaboration?

These questions can be translated in another set of questions related to providing support for social awareness in interactive systems. The questions we will treat in this thesis are:

What information is relevant for social awareness and how could it be collected by the system?

How can awareness data collection that includes information on people be balanced in respect to privacy and integrity?

How can the collected data be filtered, interpreted and/or transformed in order to obtain information relevant to social awareness?

What information is to be presented to the user, when and how?

In our projects, we see that a part of the initial stages of the design process needs to be used for answering the first question stated above. While nowadays a lot of information can be collected, we must remain aware of the fact that only a small part of this information does represent relevant awareness information. As will be seen, there will be a drive to find the proper balance between what kind of information is collected and what is relevant. It is the task of the designer to understand which of those elements are of higher importance for the given situation and what information is really needed for each of the elements to work in a proper way in the computer mediated system.

Moving to the second question, while automatic collection of data about users is simple nowadays, all such methods raise serious concerns about *privacy*, as previously identified by researchers (e.g. Clement 1994). While people have found simple, natural ways to deal with face-to-face awareness information, having a computer system record what one does, when and how, does tend to make people uncomfortable and concerned.

But if automatic data gathering comes with such problems, the alternative of having the user enter the data manually is no solution

either. The problem here is that it would take the user too much time to enter the information (Grudin 1988). Additionally, we have to keep in mind that providing awareness information is seldom the main task of the user. As such, systems that rely on users to provide information, as identified by Mackay (1991), often fail as the cost of maintaining that information is just too high compared to the benefits for the users. Any user-controlled mechanism will mean extra work for the user, often with little direct reward to him. Finding a balance between automatic and personal gathering of data will be addressed in the projects presented. While numerous alternatives have been suggested, as we will see, it will be up to the given application and situation which solution is best applied and in what specific form.

Another aspect of awareness that will need to be addressed in the design process is what *interpretation of the collected data* the system would need to do. As the collected awareness data can be detailed, limited bandwidth in communication systems normally allows for only a fraction of that amount of data to be transmitted to the other users. Some sort of selection and interpretation of data is required so that higher-level information is transmitted instead of the raw data that is collected. The different projects presented here will take different approaches to this question, based on the findings of the initial stages of the projects or based on user feedback.

Not only extracting and filtering relevant information will be of interest here, but also the way in which all the awareness information is presented to the user and when exactly. Traditionally, this would be solved by either a mechanism where one user 'subscribes' to the awareness information that seems to be relevant to her or a mechanism where the system would 'guess' what is relevant for the user and would prompt awareness information to the user in some way whenever the system would consider it appropriate. Normally the first type of solution is limited, as it is hard for people to know in advance what is relevant in the future. Additionally users normally do not consider it important to update any change in interest or expectation. The second approach tends to annoy the user, as any prediction mechanism is still far from perfect.

Theoretical models have been proposed that mediate between these two extreme mechanisms, like the Spatial Model as well as our own Aether model, presented later in this thesis. These aim to provide generic

mechanisms to improve the identification of the relevant awareness information needed by users.

Two other relevant considerations need to be also introduced here: *bridging space* and *bridging time*. First, CSCW has come with the promise that interactive systems would be used in order to allow for collaboration regardless of the location of the involved people. In a sense, CSCW has promised to *bridge space*. When a team located around the world needs to do something together there is no problem, CSCW applications will link you up and will allow you to work as if you were in the same room. Secondly, interactive systems would also help you *bridge time*. Not only can you cooperate with other people, but also everyone can do that at her own time, as CSCW applications will cater for that.

These two promises of CSCW are also the ones that require well functioning awareness support, especially as failure in this area will lead to failure of the application (Grudin 1988). Actually, Fuchs et al. (1995) used *time* and *space* to group forms of awareness in cooperative systems into coupled-synchronous (what is currently happening in the actual scope of work); uncoupled-synchronous (what happens currently anywhere else of importance); coupled-asynchronous (what happened in the actual scope of work since the last access); uncoupled-asynchronous (what happened anywhere else of importance since the last access).

By addressing the four questions above, we will actually explore *how social awareness issues can be approached in interactive systems design?*

Additionally, inspired by our practical investigations from the various projects presented here, a theoretical model for social awareness, and awareness in general, called *Aether*, will be introduced. We will explore the theoretical implications of the model as well as the possibilities it opens for solving problems related to awareness in general. Furthermore, we will explore how other questions often encountered in digital systems design could be handled by using this model and how other researchers have used the model in answering their own research questions.

How can user-centred design methods be applied to support social awareness? Such reflection will enhance the understanding of social awareness, and will provide us with a good basis for drawing conclusions that can be used in future design situations. We will show that Participatory Design (PD) is a good approach to social awareness issues and we will reflect upon some practicalities and limitations that need to be considered.

1.3. Thesis overview

This thesis will address the stated research questions around *social awareness* by using a twofold approach. Firstly, a number of design-oriented research projects will be presented, with a special focus on the aspects of social awareness support in groups and communities of practice. Secondly, inspired by this work, we will introduce a generic awareness support model, *Aether*, and will look at the use of it, both as a theoretical instrument and as a practical implementation tool.

CHAPTER 2 will introduce the generic design approach and the methodology used in the projects presented further on.

CHAPTER 3 will present **@work**, a project where the goal was to develop a tool for improved social awareness in a small research community. This will provide us with a good occasion to lay the groundwork for the rest of the thesis as this initial project will address the issues related to awareness in computer mediated collaboration, as presented in this Introduction.

The first part of Chapter 3 (sections 1 and 2) is a reformatted version of the first of the two papers listed below, while additional information can be found in the second paper. The second part of the chapter is previously unpublished work describing some work done after the publication of these papers. The chapter ends with a section where reflections about this project are presented.

Tollmar, K., Sandor, O. and Schömer, A.: "Supporting Social Awareness @work – Design and Experience", in Proceedings of the ACM 1996 Conference on Computer Supported Cooperative Work (CSCW'96), ACM Press, 1996.

Sandor, O. and Tollmar K.: "@work - The Design of a New Communication Tool", in Proceedings of the 5th ERCIM/W4G Workshop, GMD, Sankt Augustin, Germany, 1996.

The system was developed together with Konrad Tollmar and Anna Schömer at IPLab (Interaction and Presentation Laboratory at the Royal Institute of Technology Stockholm) in 1995-96. My contribution in the project was in the analysis part of the collected material, the design of the various prototypes and the implementation of most of them. Konrad Tollmar worked with the design workshops, while Anna Schömer made an ethnographical study of IPLab. I joined Konrad later when we started analyzing the collected data and designed the first prototypes. Since then,

the two of us worked closely on the issues surrounding awareness and on developing new ideas for the prototypes, which were mostly implemented by myself. I was also active in the evaluation part of those prototypes. This work has also been presented, from another perspective, in Tollmar et al. (1994) and in Tollmar and Sundblad (1995).

CHAPTER 4 presents three projects addressing social awareness in communities. The first two, Saxaren and Svenskwebb, describe two settings within a project called Copland (Groth et al. 2006b). The goal of the project was to study how IT could support knowledge transfer among professionals that work in a loosely coupled way or in isolated situations. The focus of the research was to foster communities of practice within these organizations, as a vehicle for this knowledge exchange, and is relevant to the thesis as social awareness turned out to be one of the key ingredients for this.

In **Saxaren**, presented in more detail here, we look at ways of improving social awareness among geographically distributed teachers within the Stockholm archipelago. While the chapter is a reinterpretation focusing on the issues of social awareness, it is based on the work described in the following papers:

Groth, K., Bogdan, C., Lindquist, S., Räsänen, M., Sandor, O., Lindskog, T.: "Creating a Space for Increased Community Feeling among Geographically distributed Teachers." in Proceedings of the 4th decennial conference on Critical computing: between sense and sensibility, 145-148, ACM, Aarhus, Denmark, January 2005.

Groth, K., Lindquist, S., Bogdan, C., Lindskog, T., Sundblad, Y., Sandor, O.: "Saxaren - Strengthening Informal Collaboration among Geographically Distributed Teachers.", in Proceedings of OzCHI, ACM, Australia, November 2006.

Kristina Groth, Cristian Bogdan and I have carried out most of the work, Kristina being the lead person for this setting. Most of the activities like workshops, questionnaires, design of prototypes, discussions, etc. involved all three of us. Sinna Lindquist and Minna Räsänen helped us with methodology aspects while Yngve Sundblad provided the supervision of the project. Cristian Bogdan and Torbjörn Lindskog implemented the prototype.

In **Svenskwebb** we designed a system addressing the needs of teachers of Swedish at foreign universities with the goal of fostering a community of practice among them. The work done has been described in:

Sandor, O., Bogdan, C. and Groth, K.: "Cooperative Learning through ICT: the Case of the Swedish Teachers Abroad", in Proceedings of EISTA 2005, Orlando, USA, 2005.

Cristian Bogdan, Kristina Groth and myself did the work. Most of the activities, like workshops, questionnaires, design of prototypes, discussions, etc. involved all three of us, while I had the coordination responsibility. I implemented the prototype of Svenskwebb and I was the main author of the paper while my other two colleagues contributed with parts of the text and provided comments and revisions to the draft.

The chapter also briefly presents **Ajmo Splite!**, an intense project done with a group of PhD students at a Summer School in Split. It focuses on raising awareness of the local community regarding sensitive and relevant planning issues. This experience has been described in:

Baillie, L., Phillips, A., Roberts, J., Lindquist, S. and Sandor, O.: "AJMO SPLITE: Come on Split Tell us What You Think!", in Proceedings of the Critical Computing Conference, Aarhus, Denmark, 2005.

All work, concepts, ideas, implementations and evaluations were done together during the intense days of the school. Everyone participated in all activities, from interviews to different analysis and design sessions, making of the prototype and evaluating it on the streets of Split. The group consisted of Sinna Lindquist, Anthony Phillips, Joi Roberts, Erik Markensten, Martin Tomitsch, Kateryna Falkovych, Matthias Müller, Branimir Kolarek, Antonija Skugor and was led by Lynne Baillie. The form presented in this thesis is my own reflection on the work done, with special attention to social awareness, the use of methods and the results in relation to the other projects and questions of this thesis.

CHAPTER 5 presents our theoretical model, called **Aether**, which can be used as a generic awareness support approach in collaborative applications. Based on the following paper, the chapter presents all concepts of the model as well as the theoretical implications of it.

Sandor, O., Bogdan, C. and Bowers, J.: "Aether: An Awareness Engine for CSCW", in Proceedings of the Fifth European Conference on Computer Supported Cooperative Work (ECSCW'97), Kluwer Academic Publishers, 1997.

The idea of an awareness mechanism for desktop applications (as opposed to VR spaces), as well as the idea of using the concepts of the Spatial Model for that belong to me. Cristian Bogdan and John Bowers joined me at the time of putting together the various ideas that later formed the Aether concept. Cristian made the major part of the implementation of the engine described in the paper. The paper was written by all three of us in equal parts while I drove the writing process. Later theoretical developments, like the Aether metric, are my contribution.

CHAPTER 6 presents applications of the Aether model, both within the initial real of awareness support for collaborative applications and in Shared Virtual Environments (SVR), where the Aether metric allows for integration of geometrical and semantic awareness. A detailed presentation of **Heatmap** is included, a project based on one of the ideas inspired by the Aether model. Last but not least, we will look at how other researchers have used the Aether model either as a theoretical concept for their work or as a practical tool for implementing awareness support and other functions.

Most of the ideas have not been published till now and have been developed together with Cristian Bogdan, John Bowers and Kai Mikael Jää-Aro. The Heatmap described here is part of the Daphne project on Digital and PHysical iNteractive Environments (Sundblad 2005), while the ideas around Heatmap originate from my previous work on awareness. Some of the concepts have been influenced by the work of Cristian Bogdan, while the prototype was developed together with Pär Bäckström, Karl-Petter Åkesson and Mariana Back.

CHAPTER 7 contains a discussion that brings forward thoughts and ideas that expand those presented in relation to each individual project. We will provide a systematisation of the considerations from this thesis and we will discuss the different design approaches used and the way in which the chosen methods have influenced our findings and our designs. After this discussion, we will end the thesis by drawing some conclusions, mainly by answering the research questions stated above and by suggesting a number of implications for design.

Contributions of the Thesis

The thesis contributes to the field of HCI and of awareness research in a number of ways, listed below and (more elaborated) at the end of the thesis, Section 7.4. To start with, one of the projects presented here is responsible for *introducing the concept of social awareness*.

Based on the investigations from this thesis, another contribution, useful for interactive system design practitioners, is the *systematization of social awareness on various criteria* (see section 7.1). We will also contribute by identifying a number of *implications for social awareness design* and by providing *insights into use of design method* in relation to the focus of the thesis (see Chapter 7).

Having done some of our projects in community settings, the thesis will also contribute with a relevant *investigation of social awareness in diverse communities* (see Chapter 4 and final chapter).

Last but not least, the thesis contributes with a theoretical model called *Aether* that proposes a model of handling awareness in semantic networks as well as in hybrid systems where shared VR environments are augmented with semantic information (see Chapter 5). As the impact of this model has not been limited to the researchers proposing it, we will dedicate a chapter to a discussion of how Aether is applied by us and other researchers (Chapter 6).

The long (for practical reasons) research study period gave us the opportunity to assess the impact of some of the contributions of this thesis as citation numbers. The highest impact in the HCI community lies with the *@work* and the social awareness concept (135 citations¹) presented in Chapter 3. The second highest lies with the Aether model (78 citations).

¹ According to Google Scholar

2. Methods and approaches

In order to address the research questions that this thesis raises, we have taken a design-oriented research approach (Fallman 2007). By approaching a number of different settings, by experimenting with a number of technologies and ways of approaching awareness support, we have experienced first hand the issues raised in the Introduction and we have, hereby, investigated answers to our research questions. We will use this experience, in a *reflective practitioner* way (Schön 1983), to discuss the similarities and the differences that these projects have highlighted in order to come to a number of conclusions and recommendations on social awareness.

Besides this overall approach of the thesis, each individual project has used a certain design process, or design approach, as well as a number of methods specifically chosen for the design task at hand. While these processes and methods are properly introduced and presented in each chapter that describes the projects, all of them share a common approach and design process. This process, we feel, needs to be briefly presented, as this will provide the proper background to understand the specific methods used in this thesis.

2.1. The Design Process

The design-oriented projects presented in this thesis use a traditional iterative design cycle, as depicted in a simplified way in Figure 2.1.

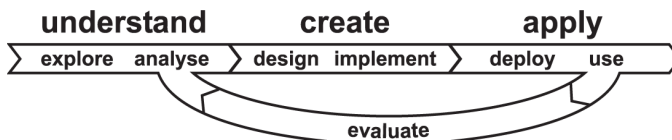


Figure 2.1 Generic iterative design process

‘Understanding’ is the part in which a number of methods are used for helping the design team gather a coherent, detailed view of the context of the design problem at hand. Normally, this includes a better understanding of the users/people/ stakeholders involved and the space, time and activities that form the context of their life/work as well as their values, aspirations, needs and wants. This stage is of a strong exploratory nature. Very often the designer enters the scene with very little expectations of what needs to be addressed. This initial investigation is central especially in projects where there is no clearly defined problem area, but where a setting or a group of people and some first issue are the initial starting point.

‘Create’ is the stage where, based on the understanding gained previously, a new situation is envisioned, designed and implemented. Versions of the design might be created and selected, etc.

‘Applying’ the design means deploying it to the user, having the target group use it and it is normally accompanied by some sort of evaluation of the new use. It can be seen as the step where the new design solutions are applied in order to improve the situation found in the beginning.

This cycle is repeated in an iterative way, starting very often with the smallest set of identified issues and by designing initially simple types of prototypes that are used not as much for the solving of the problem but rather as tools to better explore, through evaluation, the concepts and concerns at hand. With each iteration the understanding improves, the analysed issues more expanded, the prototypes/systems more elaborated and closer to the final design.

These stages and steps are of course not completely separate and there is overlap between them. It is common that one starts the design step even if more exploration is still ongoing, or while implementing some detail requires going back to analysis, etc.

2.2. Participatory Design

Sharrock et al. (1994) argues that most CSCW “failure [is] often attributed to the inadequacy of existing methods” since traditional requirement specification pays insufficient attention to the social context of work.

It is our belief that a broader perspective on work and environment needs to be considered. From a holistic perspective, work is

fundamentally social, involving cooperation and communication, with few work tasks being done in isolation.

Bannon (1991) proposes that the design process should be directed towards an "...understanding [of] people as actors in situations, with a set of skills and shared practice based on work experience with others". He stresses the importance of going from user-centred to user-involved design by applying common design techniques, such as prototyping and iterative design, instead of requirement specification and traditional human factor analysis.

Considering the fact that social awareness falls within the social context of work, and considering that related issues are of an informal, tacit nature, all of the projects presented here have been carried out by approaches grounded in the Scandinavian tradition of Participatory Design (PD) (Bødker et al. 2000). As expected, each specific project, based on the setting, on the design goals, on the target group or community, etc. needed consideration on which exact methods needed to be applied, but all have been chosen from within the methods, approaches and practices of PD.

PD is a set of methods, approaches, theories and practices that put at the centre of the design process the quest of better understanding the needs and wishes of the users. Instead of using just formal requirement description, this approach is trying to better ground any design concept in the real life and work of the people that will later interact with the new technology that is under consideration.

Not only that, but it strives to involve the users themselves as active participants in the design process. PD can be traced back to the 70s when Nygaard started working with metal workers in Norway on workflow computer support (Nygaard and Bergo 1974; Nygaard 1979). The approach used there inspired a number of projects in Sweden in the late '70s and early '80s, for example DEMOS and UTOPIA (Ehn 1990; Bødker et al. 1987). The goal was to involve workers and local unions into the design of new technology.

This had a two-fold reason. Firstly, it was to allow the workers' perspective to be the starting point of the new system design. This was considered more democratic and was in line with the Scandinavian societies' aspirations at that time. Secondly, there was a hope that by involving the future users in the design of any new system, a better

understanding of the problems and possible solutions were introduced at a very early stage in the design, thereby improving the chances of success of the technology.

Based on those experiences, a number of researchers (Greenbaum and Kyng 1991; Ehn 1990; Bødker and Sundblad 2007) have called for, and practised, PD, and HCI in general, to strive to involve the user fully in the design process, not just as an information provider to the designer, but as an active decision-making member of the design team. User involvement should also mean creating new ways for designers and users to work together (and not just fitting users into an already existing system development process). Thus Participatory Design is not a single theory or technique, but rather an approach that is characterized by concern for humane, creative, and effective relationship between those involved in technology's design and its use (Bødker et al. 1987; Suchman et al. 1993).

A number of practical common elements can be recognised in most PD practices. While these practices were initially stated having in mind working situations (Bødker et al. 2000), they have been evolving into practices used in general design of interactive systems:

- PD recognizes that people (users) are a prime source of innovation, that design ideas arise in collaboration with participants from diverse backgrounds, and that technology is but one option in addressing emergent problems or life situations;
- PD respects the users of technology, regardless of their status in the workplace, technical know-how, or access to their organization's purse strings. PD practitioners view every participant in a PD project as an expert in what they do, as a stakeholder whose voice needs to be heard;
- PD views a 'system' as more than a collection of software encased in hardware boxes; in PD, we see systems as networks of people, practices and technology embedded in particular contexts;
- PD practitioners try to understand people, their needs and their actions in their own settings; this is why PD practitioners prefer to spend time with users in their natural environment rather than 'test' them in laboratories;

- PD addresses problems or needs that exist and arise in the life of people, articulated by or in collaboration with the affected parties, rather than attributed from outside;
- PD uses a large set of people-centred and people-involved methods including workshops, low-tech prototyping, etc. with the clear goal of allowing the user to express ideas, needs, proposals and critique throughout the design cycle.

2.3. Methods Employed

Participatory Design offers practitioners not only a set of general rules and practices but also a wide repertoire of specific methods that can be used in the different stages of the iterative design cycle. While an overview of all those methods is beyond the scope of this thesis, we found it relevant to introduce here those PD methods that have been employed in the projects presented in this thesis.

In the initial stages of any of the design cycles we used a number of explorative methods with the clear goal of getting a primary understanding of the given setting, of the activity of the people active there and an overview of the present situation, with its problems, communication channels, etc. In a sense, all these methods have as a goal a better understanding of "how things really work", as opposed to "how things are supposed to work".

Ethnographically inspired explorations

An important approach of this type is the *ethnographically inspired exploration*. This kind of study is undertaken to provide a general and informed sense of the setting for the designers. It is stated, for example in Sharrock et al. (1994), that "field work methods involving ethnography are capable of providing rich material and analyses of the 'real world' character of the social organization of work". We believe that ethnography (and social anthropology) is a natural and useful basis for CSCW design because it is focused on the 'workday' activities of people in real settings.

To complement the information that we could observe ourselves, we also used *interviews* and *questionnaires*, with users as well as with other stakeholders. For example, in the case of the Svenskwebb project, as observing users was impossible due to their geographically dispersed situation, we could only interview some of them, having to resort to

questionnaires in order to find out more about the work and life of the others.

Participatory Design Workshops

Both in the exploratory stage and in the design phase we have used a number of participatory design workshops. These were used especially in projects, like @work and Saxaren, where users were easily accessible for such activities.

A variety of formats for such participatory design workshops are being used in this thesis, most in line with similar PD-inspired work, like for example in Westerlund (2009).

The applied format was specifically considered in each instance, but in some situations we used formats suggested by other researchers in the field or we used certain existing formats or approaches as inspiration to our own participatory workshops.

FUTURE WORKSHOP. This method, as described in Kensing and Madsen (1991), is a participatory design technique that states a common problematic situation, generates visions about the future and discusses how these visions can be realized.

The method was originally developed to support discussion among citizen groups with limited resources for decision making in public planning. In this method two facilitators strictly regulate the conduct of the group. The key idea is that you should never directly criticize a speaker. Statements are written down on PostIts and arranged on a white-board to be later argued, grouped and eventually ranked.

OBSERVATION & INVENTION. This method was developed by Verplank et al. (1993) to design products with a broad audience, e.g., consumer products. Although the method was originally intended for designers, we modified it by letting the users participate in the design process. Hence, the design records became unique statements of the participants' understanding of their situation. In general, our results followed earlier studies (Bødker and Grønbæk 1991), which claim that this form of situated design has a strong impact on how a system will be anticipated and used afterwards.

The key idea behind Observation & Invention is the use of different media to keep a record of the design process, which ensures rich findings that engage the whole group. It is important to capture early

observations of real users in real contexts. Based on these observations, future characters and scenarios are formed in order to move the stage to a future use of a virtual system. Finally, metaphoric exercises guide the invention of a conceptual model and artefact representations.

PERSONAS. This method was pioneered by Alan Cooper (1999) and is based on creating fictional characters to represent the different user types. They are representations, normally captured in a 1-2 page description, and include behaviour patterns, goals, skills, attitudes and environments, with a few fictional personal details to make the persona a realistic character. In order to collect the understanding needed to create personas, both ethnographically inspired exploration and interviews/workshops with users can be used.

In our case, while we did not use the complete personas methodology, we structured one of the workshops so that these personas descriptions would result at the end and would give us a better understanding of our users.

Prototyping as probing

Another explorative method that has been used by us in, for example @work and Swenskwebb, was that of *prototypes* as probes (Hutchinson et al. 2003). The goal of these prototypes is not necessarily to try to provide a solution for the given situation, but by its fast deployment, to sparkle the discussion with the users. In such prototypes the goal is not to 'get it right' but rather to challenge, to provoke and to understand.

Conclusion

To conclude, we use in all our design-oriented projects a number of methods in the spirit of Participatory Design. Within an iterative process, we explored, analysed, designed, implemented, deployed and evaluated the setting and the interactive systems envisioned, using not one method but the broad spectrum of PD methods and approaches. In this way, by triangulation (Mackay and Fayard 1997), we have a variety of viewpoint of the problems at hand and we can better understand subtle aspects of the issues at hand.

3. @work

- Supporting Social Awareness

This chapter presents a project called @work. The goal of the project was to design and study a computer based tool intended to strengthen social group awareness within a research laboratory.

While it was performed in the early '90s and, as one will notice, the technology used might seem simple and ancient by nowadays' standards, nevertheless it offered a very good chance of addressing a number of significant questions about people working together and how awareness mechanisms could be used to improve this cooperation. By doing so, it lays the ground for the other projects of the thesis as most of the issues, concerns and problems have remained of interest, despite, or maybe because of, all the new technologies that have become mainstream in the meantime.

Not only will this work allow us to identify interesting arguments and points of view for our final discussion, but it will also provide interesting insights into the design process used and into the way in which the PD methods have helped us both in identifying the relevant issues to be addressed and in finding solutions for these needs.

3.1. Introduction²

IPLab, 1985-2005, was a multi-disciplinary research laboratory that mainly focused on Human Computer Interaction (HCI). In 1996, the lab consisted of about 10 senior researchers and about 15 research students. It was responsible for research and education at a Master's level in Computer Science, mainly in HCI, CSCW, graphics and object-oriented

² Sections 3.1 and 3.2 are a lightly rewritten version of Tollmar, K., Sandor, O. and Schömer, A.: "Supporting Social Awareness @work – Design and Experience", in Proceedings of the ACM 1996 Conference on Computer Supported Cooperative Work (CSCW'96), ACM Press, 1996.

programming, including supervision of about 20 Master's theses each year. The physical proximity of its members provided normally a natural way for spontaneous meetings, as well as for developing human relations. Nevertheless, even if physical proximity existed, it sometimes failed to yield these advantages. One reason could be the working habits of the people working in the lab.

The system described in this chapter was intended to provide similar advantages as physical proximity through computer support, bridging the gaps between people, and strengthening awareness and group consciousness among the lab members. The goal of the project was to provide a system to be used naturally and regularly by the group members to inform each other where they are, what they are doing and how they could be reached. By this we hoped to have encouraged informal, spontaneous collaboration and support community building.

On certain mornings upon arriving, the lab was full of activity and energy while on other days it was more or less empty. This could be confusing if you don't know the working habits of the IPLab people. Their work included lecturing, so they could be in classes, as well as research, so they could be in the library or in a computer room. The lab also ran external research contracts that may keep the staff out of the lab's location. The working hours were not regulated; people worked in the office or at home. Everything was fine as long as one would show up at the meetings and lectures where one's participation was expected. But it was not socially accepted to stay out of touch or to be unreachable for a long time. The 'non written law' stated that you should regularly read your electronic mail and reply within the same day in most cases. The academic world that IPLab acted in is organized in networks and, even if the lab sometimes seemed to be empty, the activity within the virtual networks seldom stopped.

One of the most important components of collaborative work, as recognized within the CSCW community, is the awareness of the activity within a group. We would like to stress the importance of *social awareness*. By social awareness we mean awareness about the social situation of the members, i.e. awareness about what they are doing, if they are talking to someone, if they can be disturbed etc. In our everyday work, social awareness is a key element. We gather continuously information about our colleagues and act accordingly. If they listen, we will talk, if they are

not here, we might phone them or leave a note. If they are in the right mood, we start a discussion, if not, we postpone it.

A definition that catches the essence of awareness in a broad way is the one suggested in Dourish and Bellotti (1992), where awareness is defined as “the understanding of the activity of the others, which provides a context of your own activity”. Moran and Anderson (1990) discuss the problem in terms of ‘peripheral awareness’. They point out the importance of signalling the availability of information and people in a way that uses the human capability to peripherally process non-attended aspects. Kraut et al. (1990) show that geographical proximity is fundamental for the development of personal relations and communication. This includes first of all the knowledge of persons’ availability, both physical and emotional. Gaver (1992) uses J. J. Gibson’s term ‘affordance’ to characterize those physical properties in a media space that provides such information.

Another aspect is the understanding of how a members’ knowledge is used in a group. Some studies, like Marmolin et al. (1991), claim that groups tend to be organized in knowledge networks where people relate to the knowledge of others. Hence, providing information about that knowledge is important, as it will increase the potential of collaboration within a group, as observed in our earlier CSCW prototypes, for example the CoDesk system (Tollmar et al. 1994; Tollmar and Sundblad 1995).

Accordingly, the focus of this work has been directed towards observing and understanding mechanisms for supporting social awareness within CSCW systems. Good communication tools will allow flexible work environments where hierarchy and strict regulated norms will be replaced by human-centred and project oriented approaches. Although the flexible work style in a multi-disciplinary research lab, like IPLab, is somewhat extreme, it has been argued, among others, by Kling and Iacono (1985), that this will become a more common work style in many settings. The need to handle ‘information overflow’ is characterized as a change in the social paradigm of our society (Kumon 1992). Information overload often seems to be handled by using other people as references rather than by excessive reading of several documents (Kedziersky 1988). One of our informants put it like this:

“For my work I’m very dependent on good social relations... If I don’t have good social relations I’ll work slowly and I neither like my work situation nor myself... A person who is good in his work knows how to use knowledge he got at previous times and has a great net of contacts.”

Notable from earlier experience with CSCW system is the difficulty to envision all dimensions of cooperative work. To explore this further, and, in particular, to study the means and expressions of social awareness, one part of the project has been to try out what we will refer to as ‘multi-domain methodology’ by using different user-centred and participatory design techniques.

Understanding the Setting

In order to get a better understanding of the setting and of the needs and wants of the users, we decided to use a mixture of exploratory methods, all based on the Participatory Design (PD) tradition.

During a two months period an ethnographic study of the cooperation and information sharing culture at IPLab was made. As already argued previously, this kind of study is assumed to provide designers with a general, but informed sense of the setting.

In order to complement these findings, we organized a series of design workshops, in which members of the group participated in the project and contributed to the design of the different prototypes that have been developed. Hence, we found a natural blend of iterative design with user involvement as an intriguing development of ethnographically informed design.

IPLab employed people with many different skills, e.g., computer science, linguistics, psychology, sociology and social anthropology. From time to time graphic designers, industrial designers and artists also worked within the lab.

Working in a multi-disciplinary community sets high standards for the members. They are not only obliged to follow the discussion within their own field, but also within the field of several other laboratory members. In order to find someone in the lab, people used a sign-in board (Figure 3.1). Placed at one of the two doors accessing the lab, it contained all staff members and blue magnetic stickers that should indicate whether you are ‘in’ or ‘out’. But since several of the Ph.D. students entered through another door, they often forgot to adjust their sticker. To use

the computer to see if a colleague is 'on' the computer network (e.g., the UNIX finger command) was seen by most as a more reliable way to check whether he/she was present or not. Still such systems offer only information regarding the use of computers, a rather limited concept of a person's 'presence'.



Figure 3.1 The IPLab's sign-in board.

The group could also use other communication programs (in the UNIX environment) that made it possible to chat over the network. Those were mainly used by the master students and by some Ph.D. students, all with a computer science background, and only if they knew each other well. A problem reported in the use of chat programs is the fact that these applications remove the normal social hierarchy, which can make users uncomfortable. This also prevents a wider usage since the risk to commit mistakes with a plausible negative social impact is felt to be high.

Many also felt unsure about when it is appropriate to use new media for communication with colleagues. An exaggerated care for a colleague's workload, especially for those who you don't know that well, was

common. Meeting face-to-face was often desired for reasons, such as the sensitivity of the subject or because of not having seen each other for a while.

The fact that working hours were not clearly regulated created problems for the lab staff when needing to reach and collaborate with each other. Several different strategies were used to overcome this. The preferred strategy was dependent on the employee's position in the lab. Master students who only spent a short time in the lab and many Ph.D. students did not raise a question to a 'superior' through a phone call, not even during normal working hours. On the other hand, the senior researchers often preferred to use the phone. They rarely hesitated to call a colleague at home if it was not too late. This is out of the question for most research students.

"... I always use email when contacting my supervisor; I never use the phone..." [Ph.D. student in social science]

For most, email was the easiest tool to use. It was a 'socially secure' way to raise a question because senders disturb as little as possible; it will be read when recipients give it time. The staff members with a higher position often used mailing lists to distribute information. The old myth "the boss is the last one to know" was within IPLab untrue since the lab leaders were those that had the contacts and the information. The different strategies to deal with mailing lists are strongly connected with the rank of the person and the social courage. Those that were talkative in the virtual media seem in most cases be the same who raised their voices during, for example, seminars.

The outcome of the first study strengthened our belief that the work within the laboratory could primarily be described as a social phenomenon. Therefore we found it important to achieve a deeper understanding of the nature of social activity in the lab. Without such knowledge a collaborative tool might not work as it could go against social norms. Harper and Newman (1996) state that social behaviour is always meaningful and, therefore, the study of social behaviour is the study of meaning. Findings from their rich material of work practices and studies why certain systems fail show that there is a causal link between system rejection and conflict with responsibilities. In the case of IPLab, the ethnographic study showed the importance of a socially secure collaborative tool which, in order to succeed, needed to support both direct and indirect communication. The tool cannot only enforce

direct communication since this would be uneasy for junior members. On the other hand, direct communication was reported as important and needed in some cases.

The second major finding from the ethnographic study was about expressed difficulties in keeping contact with colleagues and students outside the laboratory. The sign-in board was seldom used and there were many alternatives. This leads us to the conclusion that a computer-based tool aimed at bridging those gaps and strengthening social awareness among the lab's members also needs to take in consideration persons outside the lab. There seems to be a demand for providing public interfaces such that, e.g., students could see if and when their teachers are reachable. This was not taken in account in the first prototype since we wanted to start by exploring different matters and see how things work within the group.

The First Prototype

In order to improve our understanding of our users and of their community, we decided to prepare a first prototype with the clear goal of using it to involve the lab members in our development project and to use it as a sparkle for further discussions. The system was named @work, an acronym for being virtually at work.

Inspired by systems like Montage (Tang et al. 1994), Crusier (Fish et al. 1992) and RAVE (Gaver et al. 1992), we started using a videoconference tool called *m* developed by Ron Frederick at Xerox Parc. It provides thumbnail video images of all people that are using the system at one moment. The key idea is to be at all times aware of the presence of colleagues, thereby creating opportunities for spontaneous collaboration. However, as noted by Whittaker (1995) in his review of real-time video for interpersonal communication, the kinds of glances made by video do not necessarily lead to better connection rates compared to phone calling when you have no clue about availability.

One version of the prototype was used by a small group of volunteers from the lab. The size of the group was limited by the fact that the system works only on Sun stations, requiring certain computer resources and a video camera. The experiment confirmed what previous studies showed. Even if people expressed concerns about privacy in the beginning, later on they did not refer to them any more. Having this kind

of connection did not change the way people worked during the test period, but users got used to having it on screen.

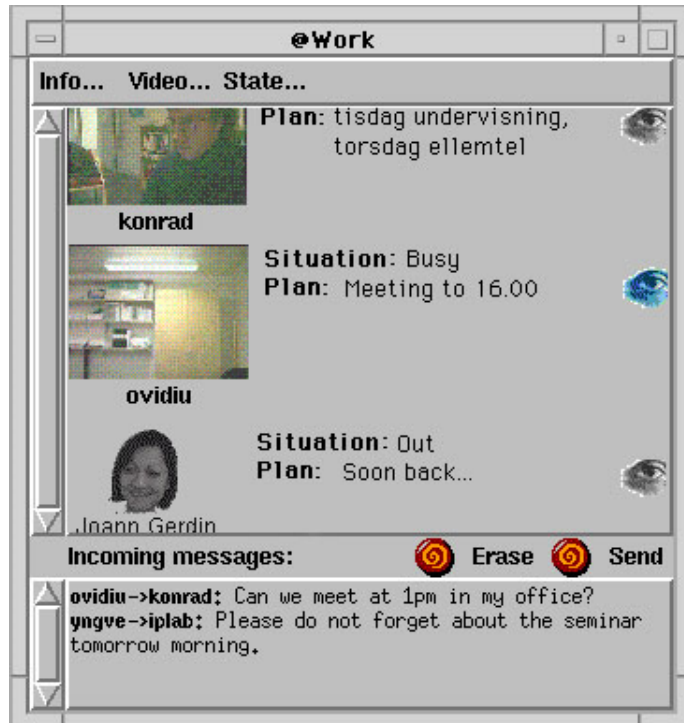


Figure 3.2 The first @work prototype.

After a couple of weeks, users' interest for the system dropped and they stopped using it. We have found different reasons for that: first, the fact that the group was restricted (by access to technology at least); second, the fact that the system was 'closed' in the sense that no one outside the group could access it (in any simple way); third, it was clear that even if video images could offer some information about the availability of the others, some sort of complementary information was needed. For example, if someone is not logged in, where and how can I reach him, or when was he last at work?

Hence, our approach became slightly different. The kernel in our system is still a number of thumbnail images (Figure 3.2) but, based on the ethnographic study, we added some explicit awareness information. First

of all, the members were given the ability to provide information about their current situation. The ‘Situation’ makes it possible to set a state indicating your availability. We had to choose between a big set of predefined situations or a free form, where it would be up to the user to describe his/her situation. The advantage of the first system is that setting that information is simple (normally by choosing one option from a menu) while the second one is more flexible. Finally we chose a very small set of states (Here, Away from the keyboard, Busy and Out), but at the same time we provided the user with the possibility to leave text information to others (a sort of ‘plan’ as in the finger utility). By this we combined the advantages, obtaining simplicity and flexibility.

We also wanted to provide support for easy, direct communication. We extended the video link with an audio one. We also provided a facility for sending and receiving small messages (a light form of email). The messages also created a kind of history of awareness information, as one of our informants put it: “it would be nice to have here [in the system] some gossip”.

We also provided a ‘watch’ mechanism. By activating the ‘eye’ next to a person, the user will get notified (with a specific sound) when a change in the ‘Situation’ information of that person appears. A typical scenario for using the ‘watch’ mechanism is when looking for a colleague. If you see that she is out or busy, you can activate the ‘eye’ and you will get notified when she resets the awareness information. Then you could call her through the video/audio link.

Design Workshops

Following the deployment of this first prototype we organized a series of design workshops within IPLab where we applied a couple of PD methods. An aim of the workshops was to encourage discussions on what kinds of problems were encountered and what kind of cooperation and communication was desired. The PD methods used, Future Workshop and Observation and Invention, tried to focus on how computers could be used in the context of the current work practice at IPLab.

During the design workshops we displayed the outcome in the lab’s cafeteria to help people to follow the process. People not able to participate in the workshops were encouraged in this way to continue discussing and contributing to the workshops. Also, people who

participated were reminded about the discussions. Thus, through the design workshops, several of IPLab's members felt that they shared a responsibility for how the system would come to be used.

Future Workshop

This method, already introduced in Chapter 2, was highly appreciated in our case. A shared problem understanding was genuinely established. During the workshop, the members realized that, in order to find each other easier, they have to pay greater attention to how they provide awareness information to others. Several valuable statements convinced the group and informed us that the kind of system that we envisioned was needed, based on the following specifics of this lab's environment:

- People do not have regular working hours.
- People have several work places/offices.
- Teachers teach in classrooms away from their offices.
- Nobody has the specific responsibility for keeping track of people (like in the traditional secretary job).
- The lab members do not generally update the sign-in board.
- When someone is calling from outside, the lab member that answers cannot see the sign-in board.
- Even if email is largely used, the phone is the most used communication tool.
- People outside the lab often report problems in reaching lab members.

The last point is an important finding of this investigation. It is too often the case where, when looking at a group, designers consider only the *within the group/community* aspects, be it communication, interaction or awareness, and ignore or do not notice the *outside the group/community* considerations.

Observation & Invention

The second workshop used the Observation & Invention methodology and had interesting results in our case, with the first two parts working fine, but with the final one encountering difficulties with the users.

Observation: One of the observations concerned Lars, a senior researcher. "A day in the life" story-board of his morning activities (Figure 3.3.) showed how he would pass the sign-in board, would observe, on the way to his office, who is really 'in', would read email, and afterwards would

go for a cup of tea in the cafeteria. The storyboard clarified for the participants that they, as a group, share a lot of communication problems. It is not just them, as individuals, who have problems dealing with the variety of media and expressions that exist. Hence, observations are a bridge across individuals and groups.



Figure 3.3 “A day in the life” storyboard.

Physical proximity is important to enable awareness of the lab members’ presence. The physical proximity of a group can offer some important advantages with respect to group collaboration. First, the shared physical space affords spontaneous meetings. These prove to be useful complements to scheduled meetings, allowing a more informal way of exchanging ideas and information. Second, physical proximity provides a natural way to develop human relations and build a real community. In the case of IPLab, the design process revealed that, because of the working habits, people often fail to meet physically. This observation informed the designer about the importance of providing similar advantages such as physical proximity through a computer system.

Characters & Scenarios: Scenarios help us look at changes in context and can be interpreted as prototypes for a range of users and preferences. In the scenarios, most people recognized a phenomenon earlier observed in

the ethnographic study: the existence and importance of people outside the lab. How those people could have access to awareness information was addressed and discussed. Among these characters we could find students who work partly as lab assistants but also family relatives who need, on a daily basis, to get in contact with lab members.

Invention: The following stage in the workshop was to try to invent some new metaphor that could be used in the design of the system. Although neat ideas were discussed, most groups within the workshop reported difficulties in finding functional metaphors and artefacts.

Conclusions of the Workshops

The informants expressed a big lack of awareness of each other. The reasons seem to be two-fold: the variety of existing media creates a division and uncertainty of which media to use for a specific situation; and problems with the physical location.

The Observation & Invention method highlighted other aspects. Especially notable is the recognition of having a shared problem and that often people outside the lab are also involved. As stated earlier, the community around the lab was organized in informal networks and obviously IPLab's problems were not only local. The members' need to communicate within their informal networks was in some scenarios described as being even more important than maintaining relations within the lab.

This issue relates to another one reported during the design workshops. The idea is that people would like to provide group specific information accessible to group members, but not to outsiders. Internal information could be sensitive and people would like to protect it from external access. Nevertheless, people would like to use the same system for informing people outside the lab about their availability. This leads to the idea that an awareness system must allow differentiated information to be provided under the full control of the user.

As reported from both the ethnographic study and the Future Workshop, the sign-in board is not used very often. Another key aspect of social awareness becomes how this kind of information is gathered. Basically a computer system can automatically trace user activity and can deliver this information to other group members. As noted in previous studies of computer communication tools such a way of gathering the information can make the user feel invaded in privacy. The opposite of

this method is user-generated awareness information by means of an explicit action. In this way the user can decide what information should be accessible to the other group members. On the other hand this can lead to problems, as the price of maintaining the others informed could be higher than the benefits of the system. As Grudin (1988) argues, this is one of the major causes for rejecting CSCW systems.

If we compare this with real life awareness, we can identify the same ways of gathering information. If we are looking for a colleague and she is not in her room, we might see that while passing by (implicit information). On the other hand, if she is willing to inform us, she might leave a PostIt on the door with the phone number where to be reached or the time of return (explicit information).

The design workshops generated rather contradicting results, with some users asking for automatic information while others claiming privacy. It became obvious that we had to leave this problem under the control of the user, as other studies (Dourish 1993) also suggest.

At the other end, the receiver's, we have the problem of how to display the information. Normally, awareness information about a whole group will overwhelm the receiver. As pointed out by Gutwin and Greenberg (1995) "a trade-off between being well informed about other's activities but being distracted by the information" must be made.

Awareness information can be presented to the receiver in a passive or active manner. In the passive case it is the responsibility of the user to explicitly look for the information he/she needs. In the case of active systems, the user will be notified automatically about changes in the awareness information. The first approach has the advantage that the user is in control of when and what information is displayed, avoiding information overload by these means. Nevertheless, the disadvantage is the fact that in order to monitor the change in the state of a person, the user has to access that information repeatedly.

We suggest the use of a mixture of the two methods: a selective active information display. In such a system, the user selects what information is to be displayed actively, while the rest will be passively displayed. The disadvantages of the two methods are removed and the user is in control of the information presented. The 'watch' mechanism in our first prototype is an example of this kind of 'subscription-based notification'

services. The GroupDesk system (Fuchs et al. 1995) suggests a similar solution using subscription in a generic local event mechanism.

3.2. Design for Multiplicity

One of the most important findings of the workshops was the fact that, in order to have a usable system, we had to provide all group members with easy access to it. The system has to be accessible in different circumstances (including working at home or in some remote location, or in situations where computer resources are limited).

In order to accommodate all these particular requirements, we decided to provide three different interfaces to the system, each of which allowing access to the same information: an improved videoconference version, a web interface and a simple, plain text UNIX command. All these versions use the same data distribution and storage module, CoObjects (Sandor 1995), allowing them to work together as a single system.

The goal of the web interface (Figure 3.4) is to offer the @work functionality to all potential users. As web-browsers were available on all existing platforms, this interface could be accessed by anybody within the group. In addition, this interface can be simply accessed by someone from outside the group, as no special program is needed.

The fact that the web interface allows public access to the system raised again the issues of privacy. People would like to provide group specific information accessible only to group members, but not to outsiders. The solution was to offer two versions of the information: one for group members (protected by individual passwords) and one for public access. The Plan information from the video interface is split into 'internal announcement' and 'public plan'. The first one is accessible to group members only, while the second one is visible to anyone.

The interface consists of a number of pages that allow viewing the group awareness information as well as updating your own information. The main page presents the group members in the form of a list. Figure 3.4 shows a snapshot of the private version of the main page (accessible to the group members only). In addition to the text-based interface, this one uses the capabilities of HTML and the WWW, providing hyperlinks to home pages of the group members and to the communication tools within the browser (email). Other pages were available for viewing the

public data (accessible to everyone), pages for setting your own information (by using a form), on-line manual, etc.



Figure 3.4 The WWW interface of @work.

Figure 3.5 illustrates the use of the plain text UNIX command. The accessed information is the same as in the other interfaces. The user can view the awareness information about any group member or can set his own information. Authentication will be performed if needed.

The third interface is an improved version of the *m*-based videoconference tool described earlier. The intention was to make it look like the Web pages, for example providing a picture of a person if a video image is not available. This interface was intended for group members only. All the video/audio conference capabilities were still available while we removed the messages since those could not be naturally implemented in the web version.

```
~@sbrehm> ipfinger -p ran
Name: Ragnar Johnsson
Situation: Away from keyboard
Phone: 08-7906283, 070-7961776
Last seen: Oct. 10 09:45 on sbrehm
Internal announcement: 12/10 Ericsson, 13/10
SGN/Kista, 30-31/10 & 1/11 vacation, 7-11/11
conf: Doors in Amsterdam.
Public plan: Mostly here v40-41, except w-days.
```

Figure 3.5 The UNIX text interface.

We suggested earlier that gathering the awareness information must be done under the control of the user. In our system, we decided to collect some of the data automatically (latest used computer, latest update to the information). More sensitive information (situation, private/public information) is not gathered automatically, but we provided the user with a tool, the already described *finger* Unix command. If used in the `.login` and `.logout` file with the appropriate parameters, it can set most of the awareness information properly, reducing the user's effort of keeping the information updated.

Usage and Feedback

The first real user test was pursued over a period of approximately four weeks. This was a hectic period for the lab, several of its members being engaged in the organization of a large conference, ECSCW'95 (Marmolin et al. 1995). Naturally, there was a big need for informing each other about where they could be reached, when and how. The system became extensively used and we were able to gather many valuable comments.

The first conclusion was that the most used interface was the web one. We found that certain characteristics of the Web contributed to this. As we already mentioned, the fact that browsers are available for all platforms makes the system usable for all group members, as well as for people outside of it. Another remark was the fact that certain users had their browser open on their desktop all the time, so it seemed natural to use it to get information about some colleague. This seems to follow the current trend of integrating a variety of information services into the web-browser, so that it becomes the entry point to the Internet (Dix 1996).

Even if IPLab members expressed the importance of the concept of separating public from internal information, several of them indicated problems in doing this separation in practice. As a result, several

members provided information either in the internal or in the public field, leaving the other one blank. As Okamura et al. (1994) found in their study of news-systems, there is a need for setting the social conventions in using this kind of tools. We took the design decision earlier not to clutter the interface with options, but rather leave a couple of open text fields to be freely used. In practice, the initial users adopted a certain way of using the system, by this setting up a social norm that was later followed by the other members of the lab.

In some cases the users reported that even if information was available about some colleague, they could not rely on it as they had no guarantee about the consistency of that information. Messages like “I will be here tomorrow!” could be seen both on the physical check-in board and in the @work system. Does ‘tomorrow’ mean really tomorrow in such a case? Or does it mean today or the day before? Hence, an awareness system must provide clues about the consistency of the data. We decided to add the time and date of the last update in the awareness information. The user of the system can, in many cases, use that to validate the data presented to him.

Some people commented that the awareness information was rather formal and it could not express emotional states. During the design, some ideas popped up about how this information could be provided over distance. We would like to share two of these ideas. The first idea is that of representing the user by a ‘smiley’. The user can control the degree of smile or sadness on the face of the smiley. By this simple operation he/she can pass over complex information about emotions and/or availability. The second idea uses the metaphor of weather for the same purpose; sun, clouds, rain and storm could be used as a simple, but expressive, vocabulary.

The public interface provided the required awareness information for people outside the lab. However, some of these persons mainly used the phone for reaching lab members. To overcome this problem, it was suggested to connect the @work system to the telephone switchboard of the university. This would have made an important improvement by providing a public interface for people without network access.

Redesign - PDE Integration

As the Web interface was the most popular, we decided to focus on its redesign. The goals were to provide the phone switchboard system

connection within @work, to improve the way information is displayed and to simplify operations for maintaining up to date information in the system.

One of the recurring observations was that it took too much time to set your own information: the user had to scroll down the list (as he is presented as the last one), had to click on a link, had to complete the information in the form that appeared, send it, get a confirmation and return to the main page. In the new interface (Figure 3.6), by using frames, we have a small form with the essential awareness information from the phone switchboard always on the screen. In this way we not only made the task of setting one's information simple, easy and direct, but we also emphasize the need for frequent updates.

In order to avoid information overload, we provided a view that contained only the most important data, creating thereby a glance view of the information. The layout was intended to copy the physical check-in board, to offer an effective group overview and, at the same time, to suggest the way in which the system should be used. To make the visibility and accessibility of the new system even greater, we placed a public terminal close to the physical sign-in board in the lab. It gave a handy access to the system for people visiting the lab.

In order to get another perspective, we asked a group of students to design a sign-in board that allows students to search for each other as well as for teachers and other employees.

We provided the students with background material and gave them the possibility to interview a couple of the lab members. Their conclusions had a lot in common with our ideas. The rare use of the current sign-in board is due to location and, even more important in their perspective, group members have no real need for it. In their opinion the lab members can find their colleagues rather easily.

The discussion after the trial period and the students' redesign revealed the importance of improving both the internal and public view of the system. For the latter, the integration of our system with the phone switchboard proved to be a promising idea. As with most modern phone systems, one could leave and retrieve messages using one's phone, but many found the interface (different codes entered by pressing the phone's keys) non-intuitive and hard to use.

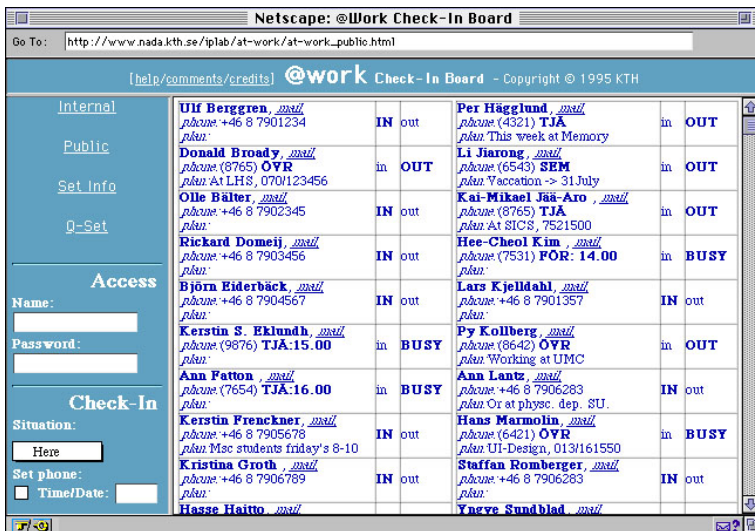


Figure 3.6 The redesigned WWW interface.

To better understand the way in which people use phone programming, we interviewed some of the PDE operators. They handled well over 2500 people and 3500 phone lines. They confirmed that most people did not ‘program’ their phones due to the tricky interface. Based on earlier positive experience when email was introduced to communicate with the operators, they really liked our prototype with the PDE integration and thought it had the potential of relaxing their workload. From their routines, we learned certain practical ways of locating a person, for example, by calling the office ‘neighbours’ of an unreachable person and asking for his whereabouts.

3.3. Later developments

By the time we were testing the latest versions of the @work prototype, IPLab needed a new web site. Having a ‘proper’ web site has become a requirement for any serious researcher as well as for any research lab. Books and theories on good web design were being published and the academic world was in a frenetic activity of transforming the first generation pages (the ones where the information was the most important while the looks took a second place) into ‘modern’ web sites with good quality graphics, etc.

Relevant for our inquiry and discussion on awareness was the fact that the redesign process of the web pages pointed out the fact that people wanted the @work system integrated in the peoples' and the lab's new web pages. Another relevant aspect for us, along with findings from projects to be presented later on in the thesis, was the fact that the proposed design generated in practice a *knowledge network*. This concept was previously defined by researchers in this field, notably by Marmolin et al. (1991), as providing both people within the group and those from the outside with information on what each person is working *with* and is interested *in*.

At the same time a number of ideas discussed and developed during this activity have generated the theoretical model Aether, presented in a later chapter. Last but not least, time has proven that the web site developed then was to be used for more than ten years without any major change. Looking back at the design decisions offer us a good opportunity to reflect and understand what made these pages an important part of the lab's information exchange for such a long time.

Web Pages Redesign

The goal in the following paragraphs is not to lecture about web page design, but rather to look at the design process, the approach that we took, given the setting that we had. The discussion that follows concentrates not on the technology, which is rather mundane, but on how it could simply satisfy the need of the group it was intended to serve and how it has evolved over the last 10 years.

By using a PD approach, the first step we took was to discuss with a number of colleagues about what they found of importance related to the web pages: what information should be there? How should it be presented? How should one be able to update the pages? Etc. The same discussions took place with the senior staff of the lab. Based on this information, we created a list of user profiles that would be 'targets' for our pages:

- STUDENTS of the university: as the lab does a good deal of teaching, it is often students that look for information on the site of the lab; this could be information about a certain course, information about a teacher, etc.
- RESEARCHERS from around the world: the lab works also with a number of research projects; other researchers could be

interested in finding information about these projects, about the published papers, as well as about the people involved in the different areas of research.

- **FUNDING AGENCIES and INDUSTRY:** people working for them would be interested in the state of the different projects, in research areas that we are interested in or in contacting some lab member.
- **GENERAL PUBLIC:** we would expect people that do not fall under the previous categories might want to get general information about the lab and its members.
- **IPLAB MEMBERS:** last but not least, the group members themselves are intense users of the site. They look for information about their colleagues, about papers, the next seminar to attend or new courses.

In terms of how the site should be designed, we gathered a number of important requirements from our discussions with our colleagues. While some of these requirements were intuitive, others were contradicting. We summarized the findings to the following criteria:

- **PRODUCTIVE AND PLEASANT BROWSING EXPERIENCE:** the site should be a good tool for people looking for information, while at the same time, it should provide for a pleasant experience. Some users might just happen to reach our site. In such cases, it is important to wake their curiosity in further exploring the site.
- **SIMPLE, CLEAR STRUCTURE:** in order to allow people to find the needed information, the site should have a simple, clear structure.
- **FLAT TREE STRUCTURE:** in order to keep the structure simple, we decided the site needs a 'flat' tree structure.
- **GOOD DEGREE OF UNIFORMITY:** we came to the conclusion that, in order to have a good site, we needed some degree of uniformity in the way in which projects, people, papers or courses were presented.
- **KEEPING CREATIVITY:** we noticed that some people had put a lot of time and creativity in the pages that they 'maintained', mainly personal page, project pages or their course pages, and we did not want to impose a uniform solution which would not allow for such creativity in the future.
- **JUST ENOUGH INFORMATION:** while the goal was to provide a good description of the lab, we soon understood that it was

paramount to put on the web just the needed information, so that it could be easy to maintain, to find and to read on a screen.

- **CLEAR, SIMPLE NAVIGATION:** the site should provide clear and simple navigation aids next to the clear and simple structure. Both those that would be looking for specific information and those that would only 'surf' the site would need to experience a simple navigation.
- **EASY MAINTAINABILITY:** last but not least, most people expressed concerns on who would maintain such a site up to date. The lab had no person employed for such a task, and still does not have one. While people put quite some effort in maintaining their own personal page, it would be hard to ask that from people if there would not be an easy way to do it.

Central to the new design have become the pages presenting each member of the group (the personal page), the pages that presented the research areas and projects of the lab, the pages presenting the courses taught and the pages presenting publications of the members of the group.

Personal pages were supposed to present each person with the relevant information, but some certain elements were considered compulsory, like links to projects, to courses and the personal publication list.

Maintaining the site

Besides the structure of the site and its graphical look, one important aspect had to be the maintainability of the site. We knew that there would be no special person there for the maintenance of the pages. It became also clear that most of the people in the lab should have the possibility to add/change information on the site: the people giving courses should be able to add information to the courses site, the people working on a project should be able to change the description of it, researchers should be able to add their newest publications to the publication list of the lab, etc. On the other hand, not all of these people have HTML knowledge and there would be no guarantee that the structure or the graphical look would be kept if everyone would be allowed to tamper with the HTML code.

We soon agreed that a maintenance mechanism should be provided for the site, one that would comply with the following requirements:

- It would be very simple to use;
- It would not require advanced HTML knowledge or, even better, no HTML knowledge at all;
- It would ensure the preservation of the graphical profile and the structure of the site, even if different people would update the information;
- It would be preferable to place a certain piece of information on all pages that should contain it (for example, a new publication should appear in both the home page of all authors as well as on the publication list of the lab) without the need to re-enter the same information;
- It should work on all main computer platforms (as IPLab was heterogeneous in technology).

While nowadays one can use of the shelf content management systems, at that time no such concept existed. As such, we had to create our own system by using JML, a system developed by Cristian Bogdan and the author, which later on evolved into JSP (<http://hci.csc.kth.se/projectView.jsp?name=jml>).

We used this technology to create a parallel web site, called 'Edit mode'. Such a link exists on all pages and allows the lab members, after proper identification, to edit the content of a web page. The system uses the entered information to 'construct' on the fly the proper page. Additionally, the system will see to that information introduced in one page, for example, a new publication in the publication list will be properly added to the personal page of all lab members that are authors of this new publication.

The Knowledge Net

What we actually obtain is a *semantic network*, linking people, projects, courses and publications in a way as envisioned by a concept earlier developed at IPLab, the KnowledgeNet (Marmolin et al. 1991). This concept considers that people who work together have different knowledge and that they will use each other's knowledge when needed. So, instead of trying to find some book about a certain subject, a lab member would ask a colleague that might be an expert in that field. In this way, people form a network of knowledge. Our semantic network contains the basic information that relates people with knowledge, be it projects, courses or publications.

Awareness and the Web Pages

We also used the opportunity provided by the development of these pages to incorporate ideas from @work, mainly based on user's feedback. As such, in the 'People' area of the site one can see a sign-in board of the lab. As you can see in Figure 3.7, the system provides 'at a glance', important availability information about the lab members.

Based on the last prototype described earlier in this chapter, the system was connected with the switchboard of the university and exchanged information with it. In this way, phone setting information was visible for people from outside or for colleagues via the Web. The system also provided a simple interface for setting this information that automatically will also set the user's phone. The lab member just has to press the 'Edit mode' link and then he/she can use a simple Web form for choosing the different messages that should appear in the phone switchboard.

Additionally, the page of each lab member contained also the awareness information from @work relevant for that person. By this one could simply access the web page of a person in order to find out when/how it is best to contact her.

Usage And Reactions

Once the main pages had been put together and the database part was written, we decided to have a seminar with the lab members. We presented there the new pages, their structure and the way in which each person could enter information. At that moment the site contained almost no information about the projects, about the people or about the courses. Only the publication list had been entered, by converting a bibtex file.

The lab members had about two weeks for entering all the information. We were afraid that they would not enter the information in good time or that they would not enter all information. This turned out to be wrong. We later discovered that the real stimulus for entering the information was the desire that their official page should contain complete information about their activity. This made them add all their projects, their publications as well as all courses. By entering all this for their official page they actually entered all the information needed for the site. The JML system that we had built takes care of the rest, presenting all information in all relevant pages.

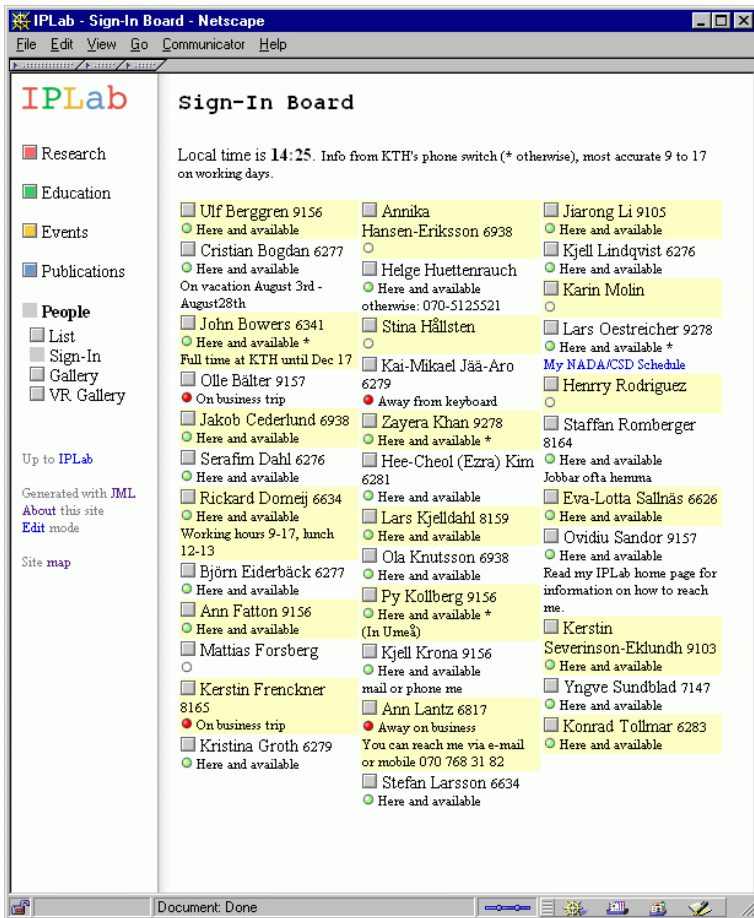


Figure 3.7 The sign-in board in the IPLab Web pages.

At the same time, we got a number of improvement suggestions from the lab members. Such an example is a 'Help' page that is available for the lab members that explains how to use the update and the @work part of the system.

3.4. Conclusions

Looking back to the @work project, we see that it was one of the first to define *social awareness* and to explore the issues relevant to it in interactive system design.

The setting of the project was a small group of people, part of a formal research laboratory. Work is the central common interest of the people involved and knowledge is the basic object of work. The project succeeded to highlight a number of issues that are still of interest to research and to the practitioner today: data collection, privacy, defining the 'inside' and 'outside' of the group and data presentation. These will be discussed in the projects and chapters to follow.

Regarding collection of awareness information, in this project, we could use user-entered data as we identified strong social and professional motivation to maintain up-to-date web pages and up-to-date availability information. In order to reduce the work of the user, bound to update similar information in a number of alternative technologies, ranging from phone to physical board, we integrated a number of technologies so that information entered in one system would be automatically taken over in other systems, if the user so wanted.

This approach, of integrating a number of technologies, was taken also in the case of displaying awareness information. As such, information collected by the system from various sources could be displayed in a single interface. For simple overview of the information of all lab members we used a *glance view* type of design to the respective web page, an approach we will use often in the projects presented in this thesis.

By using a number of Participatory Design (PD) methods of exploration and design, we have learned that 'real world' social awareness is sometimes different than the expectation of the designer. In our case it turned out that the immediate social network expands outside the formal borders of the institution and that systems like ours need to consider this aspect in the design.

Users helped us identify also the importance of clues regarding data consistency, especially in systems that rely on users to enter and to update information, where one needs to have confirmation of the validity of the available data.

The @work project started from an assumption that was popular by that time in CSCW regarding the use of 'rich' media for providing remote awareness information in cooperation systems (Boudourides 1996). The argument was that awareness information in face-to-face environments is 'transported' via a multitude of media (sound, vision, touch, etc.) and this information is collected and filtered by people. As the normal computer

based communication channels were very limited in terms of information passed from one side to the other, it must be that only provision of 'richer' channels of communication (like video) that the same natural awareness information would 'flow' from one user to the other. This would make the initial prototype fall under the Media Spaces social awareness genres, as defined in the Introduction.

In our case, the synchronous nature of video made it of little use in a laboratory where the working habits of the members mean limited time in front of their computers but permanent movement between classrooms, research areas, conferences or home, where work is sometimes done. At the end @work morphed more towards the Messaging Systems genre, where small text messages regarding ones own activity replaced the video for most of the time.

Our findings have been later confirmed by applications like ICQ, Messenger and Skype. In all these we see the same fundamental mechanism for social awareness: simple asynchronous communication over small text messages indicating physical and social availability. Tweeter and Facebook have extended the concept and their popularity is proof of the fact that the need for social awareness is as present as ever.

The contribution of this chapter to the thesis is the fact that it allowed us to identify and explore in a work-related setting the issues regarding social awareness. We have also used this chapter to provide a definition of this concept, introduced by us during the work on @work, and it allowed us to test a series of possible solutions to the issues identified. As we will see in the following projects, these issues are of relevance even today, in projects addressing explicitly or implicitly social awareness.

4. Social Awareness and Communities

The previous chapter has presented a first setting in which we considered and defined social awareness. We identified the relevant issues and we have looked at a number of experiments for treating the research questions formulated in the Introduction of this thesis. This has given us a first picture of social awareness in a traditional work-related setting, with a group of people following, more or less, formal organizational lines.

In order to deepen our understanding of social awareness, we will look in this chapter at the same research questions in a less formal setting, that of communities. Communities of practice were the focus of the first two projects: Saxaren and Svenskwebb. In both of them the goal was to identify ways in which knowledge sharing among teachers working in distributed or isolated situations could be encouraged, supported and improved with the help of interactive systems. We have chosen in both of them to attempt this by enabling and supporting the development of communities of practice. As presented in the introduction, these communities have been suggested as proper vehicles for knowledge sharing.

Saxaren will be presented at greater length as in this project social awareness proved to be the key in improving the emerging community of practice. As such, it turned out to be an interesting setting for considering the research questions at hand. We will then briefly look at Svenskwebb, limited to the themes relevant to the thesis, as it will provide us with a pertinent comparison to Saxaren.

While different in goal and approach, we will also briefly present Ajmo Split!, an intensive two weeks projects done during a PhD Summer School in Croatia. Of relevance to this thesis, the project offers a reflection on how interactive systems can play a role in sparking social awareness even in traditional communities, like the community of a city

as well as an interesting reflection on use of Participatory Design methods even under strong time constraints.

By these three design-oriented projects, this chapter will look at the issues surrounding social awareness in communities, but in a number of different settings. The different approaches tested will allow for relevant findings that will be discussed in light of the research questions in the final chapter of the thesis.

The CoPland Project

The goal of the Copland project (Groth et al. 2006) was to study how IT could support knowledge transfer among professionals who work in loosely coupled ways or isolated situations. The project aimed to look both at the technical solutions and at the social constructions that encourage knowledge to be shared and transmitted within organizations or groups of such professionals. The focus of the research was to foster communities of practice within these organizations as a vehicle for knowledge exchange.

The project started with the belief that there can be no IT system that can leverage long-term knowledge handling in an organisation without social structures suitable for facilitating knowledge dissemination, such as the non-canonical structures proposed by Brown and Duguid (1991, 2000). In the approach we took in CoPland, the social structure, its practices and the system complement each other and co-evolve. We view the researcher intervention in the setting for the creation of such structures and the corresponding systems in the tradition of Participatory Design (PD) practices.

Learning has been an important aspect in organizations for a long time. Transferring knowledge between organization members, especially indirectly from past to future members, has been approached in a number of ways. While the initial approaches were based on storing and capturing (in databases), the more recent approaches are based on nurturing 'communities of practice' within the organization, as suggested by Wenger (2002), where various types of expertise are discussed and developed. On the way, a passage from canonical, formal institutions to non-canonical, informal, member-driven communities, is not a straightforward process, as described by Brown and Duguid (1991, 2000).

The role of social awareness in fostering these kinds of informal communities is the focus of this chapter. While not always approached in a structured way, issues regarding this type of awareness and the support provided by IT systems for it can play a central role in the technical-social interplay needed for a community of practice. Thus, our presentation of the three projects will be made through the social awareness lens.

At the beginning of the Copland project we decided that we wanted to work with groups of teachers, as we considered that they could provide a good environment for testing our ideas. While most people would agree that teaching is a very knowledge-intensive activity, most would think that teachers have the prerequisites for strong collaboration among themselves, both on topics of the respective subject and on more general questions of pedagogy and daily activities. Still, we considered that while that might be the case in certain schools, especially the large ones in major cities, we found that this is not the case for many teachers.

Teachers form a group of professionals that seldom have one single workspace. They typically work both from their home and their school. Also, in school they may not even have an office. Teachers spend most of their time in the classroom during an ordinary workday, leaving few moments for social encounters and chats with their colleagues. This type of work has been also described by the term 'nomadicity' (Bogdan et al. 2006; Rossitto et al. 2007), initially observed in amateur settings (Bogdan 2003; Bogdan and Bowers 2007; Bogdan and Mayer 2009), as their work and presence is fragmented, in space as well as in time. Thus teachers have special problems with regard to developing and maintaining communities of practice. If teachers are to benefit from well-functioning communities of practice information and communication technologies may provide a viable solution.

Our research focused on the informal context, whereby such individual and professional knowledge is acquired and disseminated, and on the situations where the sharing and distribution of knowledge occur. Organizations employing teachers should not be very different, with regard to knowledge sharing, from other organizations. However knowledge sharing among teachers rarely comes to the attention of research or of the organizations themselves.

We settled for three groups of teachers, in all cases in situations where, because of the given circumstances, collaboration with other teachers is

non-existent or very limited. This chapter will present two of the chosen groups, for which two prototypes were build: Saxaren and Svenskwebb.

4.1. Saxaren³

The goal of this design-oriented research, done under the Copland project, was to improve knowledge transfer by helping foster an informal community of practice within a geographically distributed canonical organization, in our case a school (organization) formed out of five schools (units) in the Stockholm archipelago.

Understanding the setting

Close to Stockholm one finds an idyllic archipelago made of thousands of islands. Besides being a favourite destination in the summer for the tourists or for the people of Stockholm, the area is also the home of people. In that respect the archipelago is a rural type of community. Small communities are located on various islands. As a result, even most of the traditional organizations, like schools, tend to have specific structures and ways of working in these parts. In our case, one single administrative school organization is made of five distinct units, each located on an island: Norö, Stenhamn, Rovön, Sortö and Måsen. All these locations are distributed within an area of approx. 80 km² and up to 30 km apart (Figure 4.1). The principal, in charge of the organization, is located on yet another island, Duvö, well connected to the mainland, an hour's drive from Stockholm. Although distances between these units are not that big, due to limited boat traffic, especially during late autumn and winter, meetings between teachers in these units are very limited and constrained.

We chose this target group, as we were interested to see how teachers with few colleagues around for daily casual interaction could be supported by computer technology in their collaboration with each

³ The first part of this section is loosely based on the following two papers, while the rest is an interpretation focused on social awareness, specific to this thesis:

- Groth, K., Bogdan, C., Lindquist, S., Rasanen, M., Sandor, O., Lindskog, T.: "Creating a Space for Increased Community Feeling among Geographically distributed Teachers." in Proceedings of the 4th conference on Critical computing, 145-148, ACM, Denmark, January 2005
- Groth, K., Lindquist, S., Bogdan, C., Lindskog, T., Sundblad, Y., Sandor, O.: "Saxaren - Strengthening Informal Collaboration among Geographically Distributed Teachers.", in Proceedings of OzCHI, ACM, Australia, 2006

other. In order to better understand their situation, their problems and needs and in order to consider possible solutions, we started by exploring the setting in various ways, mainly by using ethnographically inspired observations combined with other forms of investigation. For this we visited three of the units and spent a number of days there observing, discussing with the teachers, attended meetings between principal and teachers. As we understood that recently a municipality sponsored IT solution has been put in place for improved communication between schools, teachers and parents, we also used questionnaires about it and had meetings with the developers/maintainers of that system. In line with the PD practice, we also organized a couple of user-involved design workshops with the teachers.

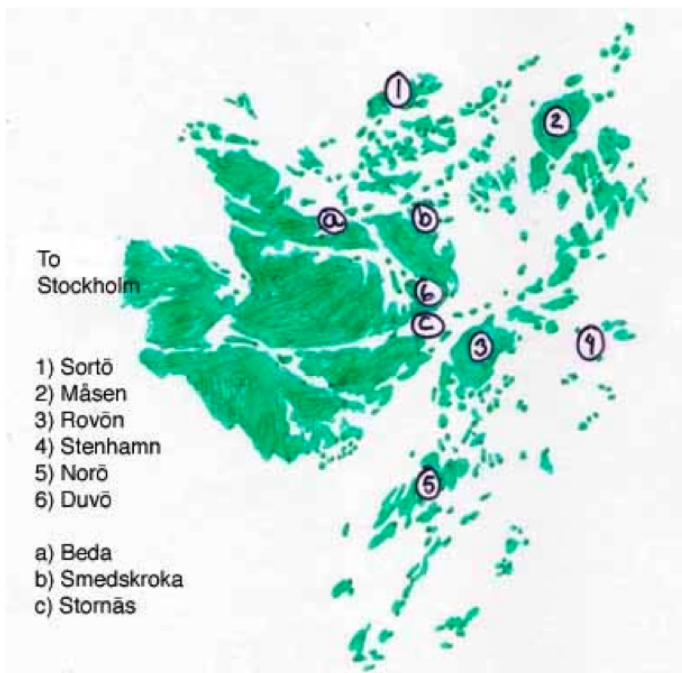


Figure 4.1 Map of archipelago schools

All these activities and methods amounted to a triangulation (Mackay and Fayard 1997) of investigations, a technique often used in PD (Participatory Design) approaches, as described in the methodology part

of this thesis. These various methods have allowed us to get an understanding of our setting from various perspectives, allowing in the end a more elaborate set of conclusions and a more insightful understanding.

All these investigative efforts provided us with an initial understanding of how teachers work, what their communication needs and means are, what problems they encountered in this form of communication, where the limits of their available technologies were, etc.

Archipelago teachers, or any other teachers in sparsely populated areas, have fewer colleagues to interact with if and when opportunities arise. Some of the units never communicate with each other, except during the management meetings. Others communicate using e-mail or phone. The principal communicates with all units by e-mail, fax and phone.

The units were highly independent and seldom relied on each other in their day-to-day activity or pedagogical work. However, the principal emphasis was that they are one single school and wanted collaboration to increase. The same can be said about most teachers who understand the advantages of closer communication and collaboration with the colleagues of the other units.

The municipality of the islands has an intranet that was introduced during our study. The intranet has one part that focuses on all schools in the municipality. Each school has its own space on the intranet where it can manage internal and external school specific information. The intranet provides forums and chat rooms where people can discuss different topics.

During our workshops, all teachers from the two of the units reported that they regularly visit the intranet to get information mainly sent by the principal. The teachers also told us that they were quite enthusiastic and entered a lot of information in the beginning. However, they soon noticed that nobody (or few of them) read what they had entered and they told us, that the introductory information about their unit still concerned the winter activities, while it was May already. Checking for new information on the intranet has to be a specific, separate activity that needs initiative and time. It is not a “push”, and is thereby easily forgotten.

The intranet used within the municipality may be a suitable support for the teachers to communicate with the principal, pupils, and parents. Due

to the complexity and the lack of feedback, it would most likely not be suitable for supporting inspiring communication between teachers. The complexity of the intranet was manifested in various ways, e.g., a lack of overview (when navigating the system) and a slow response time (when carrying out simple tasks such as login, uploading files, and following links). Therefore, "to go" to the intranet was an activity that had to be planned. It was not something you just happen to do passing by.

Our investigation has allowed us to draw a number of relevant conclusions, both for our design and for our social awareness discussion.

Firstly, most teachers understood the need for some sort of larger discussion about work, pedagogy and/or common problems with colleagues from the other units. These problems had often been expressed, but mainly distance-related problems made this type of community of practice still just a wish. We found, among other things, that the teachers want to communicate with colleagues concerning issues such as "getting inspiration" or "discussing a class".

Secondly, while a computer system had been put in place with the intent of improving cooperation, major design decisions of that system made it more suitable for formal, canonical, types of communication, like the one from principal to teachers or official reporting. While informal type of communication was also targeted, the design of that system did not take into proper consideration 'the way things *really* work' as opposed to 'the way things *are supposed* to work'. For example, the system at hand assumed that everyone would have a desktop available and almost always at hand which is contradicted by the way in which a teacher's workday is structured, with a lot of movements between classrooms, teachers' room, other places and home. This busy type of activity very seldom allows for moments when they can sit in front of the computer. Not surprisingly then, they rarely use the system, except when officially required.

Thirdly, we noticed that while canonical information exchange was present, via email, fax, phone or the municipality system, there was no support for more informal communication. This limitation meant that, while colleagues knew each other, they never succeeded to create good social interaction between units. This was something that most of them clearly identified as a problem.

Fourthly, the teachers complained that they had no way of understanding what the other units were doing, how or what problems they

encountered. Thus, even when communication happened, regardless of its form, there was very little 'common ground' for discussions and exchange of ideas and practices.

To sum up, we were facing a group of people with almost all the ingredients needed to form a community of practice but physical distance, in general, and lack of social awareness, in particular, made the transformation from 'group' to 'community of practice', if not impossible, at least improbable.

Prototypes and Explorations

Based on our findings we decided to propose as a technological solution the introduction of a computer based community notice board as a shared awareness system. This relates to previous work, like shared interactive surfaces (Izadi et al. 2003) or the "message probe" in the interLiving project (Hutchinson et al. 2003).

This decision was also influenced by our intent of using the metaphor of an instrument that the teachers were already familiar with, the notice board, which already had a number of attached social norms, understandings of way of use, expectations and clearly understood limitations. We hoped that, by *reusing the affordance* of the notice board, the proposed technology would be conceptually better perceived by our teachers from the beginning and its use would feel natural and straightforward.

Besides these considerations, we focused on building on lightweight technology, as previously suggested, for example by Fitzpatrick et al. (2002). Lightweight tools are typically based on simple technologies, avoiding heavy computational algorithms, and they are quick and easy to use. In hectic work situations, such as the teachers face every day, it is convenient, if not necessary, that the used tools are lightweight.

The design workshops organized with the teachers allowed them to envision how they would use the technology and also provided them with a good opportunity to influence our design. For us these workshops confirmed some of our presumptions and in some cases questioned some design details that we were considering.

In terms of practical design, our prototype, the *Saxaren*, is built by integrating a tablet PC into a standard whiteboard (Figure 4.2). The screen can be used as a notice board where everyone can post notes. The

integration with the whiteboard had the goal of suggesting the role of this technology. In line with trends already expressed by some researchers (e.g. Gaver et al. 2004) technology was integrated in a daily artefact, becoming almost transparent, invisible. This was indeed our goal, to provide the users with a solution that (i) would melt into their normal surroundings, (ii) would lower the adoption threshold for the users and (iii) would signal the informality of the communication channel provided.

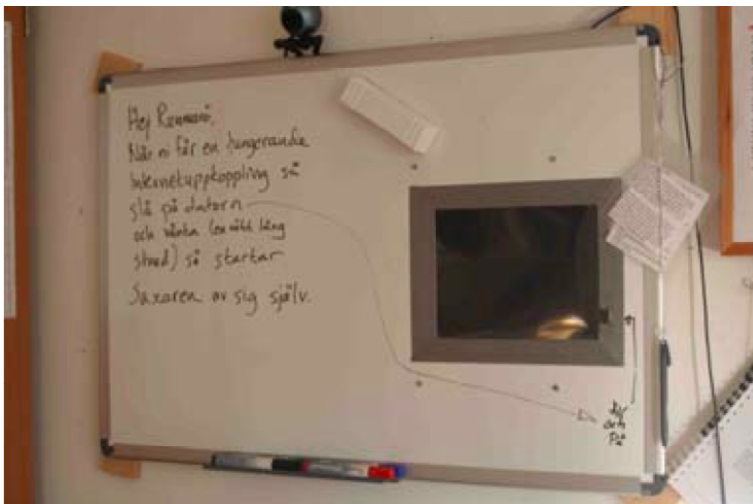


Figure 4.2 Saxaren prototype.

The system would consist of a number of such boards, each placed in one of the units of the school and one placed with the principal, while the software in the background would provide the link between all the screens so that all presented the same notes to all those involved.

The teachers said that they would use the board as a tool for posting questions, information and small discussions on work related matters: interesting articles, study visits, social meetings or pedagogical issues. This proved to be an interesting statement, as we will see later on, when analyzing the use of Saxaren, our findings went contrary to these initial intentions of the teachers.

The types of social norms that users envisioned were also of importance. For example, the users considered that there should be no demand for

replies to notes posted there. The board should be only for the use of teachers, and not of pupils. The decision to include the principal in the system or to keep the system for themselves generated discussions, as not all felt comfortable knowing that he could see the posts.



Figure 4.3 The Saxaren interface.

Based on such requests we prepared the first version of the prototype (Figure 4.3). It is a very simple system, allowing for creation of posts, all visible at once. Anyone can open one, read it, edit it, draw on it, etc. No info is provided on who made the note, who viewed it or who has edited it, etc. An attached webcam allows images to be included in posts, as seen in Figure 4.4.

In the deployment phase, when we were installing the boards, we involved yet again our users for locating the best place for each of the boards. This has been called previously "user-involved deployment" by, for example, Bogdan and Severinson (2004). Two considerations were at hand: firstly, to place them where teachers would bump into them as often as possible during the day and where they could use it impromptu and, secondly, to place them where access was already restricted by social norms only to those that were supposed to use them, that is the teachers. It was obvious that only they could identify the candidate locations and, based on discussions, we could together decide where the board of each unit should be placed.

Interestingly here, considering the privacy issue, is that we used the *privacy affordance* of the real-world space and could as such avoid this complicated issue in the design of our system. This was especially important in our case where we had to create a very simple system, so any layer of complexity added to the system, like access control, would have clearly inhibited adoption and use of the tool.

Use and Evaluation

Saxaren was used by the teachers over a period of six months. Afterwards we evaluated the system by analysing the log of the system, with special focus on the content of the written notes and on the way in which people interacted through these notes. Over the same period of time, we continued to have, at certain intervals, interviews and discussions with the users.



Figure 4.4 A typical note on Saxaren.

The detailed analysis of the notes and of the use of the system is presented in Groth et al. (2006). Statistical information of the use has been collected and analyzed, but, as far as our discussion is concerned, we consider the qualitative findings regarding the use of the system to be of central interest. These qualitative findings are inferred from analyzing the content of the notes and the way in which certain such notes 'evolved' by repeated additions to them, as well as extracted from discussions with the teachers.

The first, and probably the most relevant observation, is the fact that the Saxaren was used only to a small degree for communication directly connected to work. As stated by the teachers in the PD workshops, they did use the system for exchange of ideas for classes, questions relating to teaching material or for information regarding special activities. Still, all this represented only about one third of the total number of notes posted.

Most of the notes proved to be of a more informal nature: greetings, jokes, questions less related to work, etc. In fact, this was very much in line with our intention, of providing them with an informal, social type of interaction. This confirmed the 'work as social' theory as the work related notes were nicely complemented and encouraged by the messages of an informal, social nature.

In a sense, informality went to such a degree that it could easily have been called *playful*. Initially, that had to do with the curiosity of the users to test the system. This can be seen, for example, in one of the notes written by the principal (Figure 4.4), where he also added a photo of himself taken with the attached webcam. One of the teachers from an island drew onto his photo glasses and added to his note in a cheerful way: "You look good. How do you like your glasses?"

In the same initial stage we found other playful messages that were attempting to set up social norms for the use of the Saxaren. For example:

"Dear Colleagues! If you want to help an old lady to stop wasting time on enlarging all small squares (notes)... the lady will be happy if you erase old stuff 3 sec.... on the waste basket. Hugs!"

Or, when an empty note is found on the system, teachers from another unit added the following text to it: "Secret message??" In this playful, informal way they discovered features, tested them and slowly created the social understanding of how to use the system and for what.

After a longer period of use, when discussing with the teachers regarding the way in which they perceived the Saxaren, we found out that the system was becoming part of their daily life. For example, one of them told us that each morning, when arriving at the school, she would check what was new on Saxaren as she went about her normal routines, like checking the answering machine or putting on the kettle, etc. Other teachers reported they would ask each other "Have you checked the

screen today?", by this keeping an eye on the system and informing each other about any new notes.

What they seem to appreciate with the system was the simple interaction. The teachers liked the fact that the system was 'on all the time'. Being able to just take a *glance view* at it, while passing by or while doing something else, was also considered very good and desirable:

"...it's good that it's on all the time, good when you are in a hurry, it simplifies a lot... you don't have to look for things, everything is there... communication with the other islands is so much easier... it has increased too, the communication. We feel a little happy about it, walk around smiling..."

The informal character of the solution was something that had been in our intent from the beginning. We knew that informality would encourage communication and would improve the social context of the relation between the teachers of the different units. But we also received one comment, from one of the teachers, that she did not know the other teachers well enough to feel comfortable to write notes on Saxaren. So informality can also be inhibitive for certain people if the existing relation with the others is of a formal nature only. In such cases, solutions in the real world need to be considered to complement tools like Saxaren. This finding indicates that while technology will influence the social communication in a group, at the same time real world social interaction will influence the use of technology. This interplay of social and technical considerations needs to be addressed properly in any project by the designers.

The lightweight character of our solution, with very limited functionality, did not represent a problem, as one might initially expect. Instead, users found their way of making technology work to their expectations. For example, as there was no function in the system to see who had read a certain note, people started using the notes themselves for conveying that information when they knew it was important to signal the others that the note had been read. This could be done by putting a simple "ok" on the note, or "I have seen this", or by writing something fun on it, etc. Still, this did not mean that there was any implied obligation to read the notes but the teachers' social relations made them fully aware when such confirmations were relevant.

The 'glance view' type of interaction, as a relevant feature of the system, was strengthened by the comments of the users that cleaning up is very important so that the screen does not get too crowded. Keeping the screen to a minimum, including in terms of notes, was key. In line with this, users also asked us to differentiate the notes already viewed those not opened/read. For this we added a thicker border on the screen of a unit, around notes that were new for that respective unit. This improved the 'at a glance' perception of changes/additions to the system.

Users also appreciated the fact that using the technology required almost no effort, compared to other tools like email or the municipality IT system, where the steps needed to access the content proved to be too high for certain types of interaction. This 'cost of interaction', as defined by Kraut et al. (1990), can clearly be a major inhibitor of communication, especially in the case of informal, spontaneous messages of a social nature. Our efforts to remove any such costs, or to reduce them to a bare minimum, have paid off, as users clearly expressed their appreciation of the simplicity of the interaction.

The nature of the notes, together with the very limited functionality 'hard-coded' around the notes, have created a very interesting *content richness* that we became aware of only after looking at the way in which the system was used and after talking to the users.

Based on a digital pen with which notes were hand-written, Saxaren was a medium that could be expressive and personal. Teachers found it to be "...actually more personal because you write by hand...", adding to the informality that was one of the goals of our design.

The digital pen also allowed people to draw and we could see in the analysis of the notes that drawing was much used. For example, a number of notes took the form and content of postcards (Figure 4.4). These were again playful, not directly related to work, but very much social in nature. We consider that this sorts of informal cards would probably never have been written and would not have been posted if the proposed technology had not been so simple and so playful.

The lack of functionality that would allow users to delete parts of a note, once it was posted, led them to find ways around. For example, they would edit the note and would strike through any part that they would like to delete.

The same possibility of adding something to existing notes was used instead of the missing functionality of being able to "reply" to a note. That is, people just opened the note, read it, and, if an answer was appropriate, they would just write, draw or strike through on the note, like on a normal piece of paper.

All these hand-writings, small drawings, scribbles, etc. transformed some notes into very 'rich' messages, tracing a complete conversation, with various content, sometimes combining work related messages with fun comments, and nicely showing the way in which that conversation had come together. All this 'content richness' surely contributed to the informal, social nature that these notes have taken. So the limits imposed by the lightweight functionality could be avoided by the creativity of the users when provided with the free expression form of these handwritten notes.

This rich type of message also contains relevant awareness information. Handwriting tells one who might have written it, changes and additions help people understand the dynamics of these messages and provide the context for their own interaction with those respective notes. It is the type of awareness information that is almost non-existent in communication systems like email, where normal screen fonts have replaced handwriting and complicated functionality structures the flow of a conversation in a uniform way. These characteristics of the Saxaren make it much closer to the real-life type of awareness and as such make it more appropriate for encouraging improved social interaction between the teachers.

In further understanding the impact of our Saxaren, we need to come back to our design goal, that of helping the teachers in the exchange of knowledge. It is of relevance to ask how the use of this system has changed their school-life.

In all, we could say that the system has not made any revolutionary change to the way in which these teachers work. They still spend most of their time in classrooms and interact mainly with the teachers in the same unit. They still use the phone and email as before, or the municipality IT system from time to time. Still, the Saxaren has provided them with a new means of communication, one that is both simple and informal, and as such is a good complement to the communication means otherwise available. As envisioned by us, the tool has helped

them in improving the 'belonging together' feeling, especially because of the informal notes.

In terms of direct improvements in work-related exchange of ideas, the main function envisioned by the teachers themselves in the PD workshops, it turned out that while the Saxaren was used for such things, this was *not* the most important type of use for the system. Nor has Saxaren replaced already established channels of work-related communication, like phone, fax or email.

In terms of work-related information that had been exchanged over the Saxaren, we could notice that it was exactly social awareness information: showing to others what one does, asking for advice, sharing a new book or idea, etc. This is all information that improves the understanding of what others are doing, what others know, where one could turn to when needing help. By this, we consider that Saxaren plays an important role in improving the social awareness in the archipelago school and this contribution will lead to a higher degree of informal communication and to a more intense exchange of ideas around practices, experience and work.

Saxaren has contributed to a better social awareness of each other, an improved social interaction, which in its turn provides a better context for communication and collaboration regardless of the channel used. More than anything else, Saxaren confirmed our understanding of 'work as social activity' where non-canonical considerations like informality, play, social norms and relations have an important role as all canonical (formal) considerations like work, structures or procedures.

4.2. Svenskwebb

In this section we will continue our investigation on social awareness and its role and support for groups and communities by looking at yet another geographically distributed group of teachers, this time teachers of Swedish at universities abroad. For them we developed a system called *Svenskwebb*, which has been presented in Sandor et al. (2005).

In line with our previous efforts, our design goal was to look at ways in which a community of practice could be fostered in this group with the objective of improving knowledge sharing among its members.

In the final part of this chapter we will compare this setting with the one from Saxaren. While similarities exist, like the distributed nature of the

users, their daily activity or goals, our results in these two groups are very different and will give us the chance to discuss about the blend of technology and of the social, with our special focus on the role of social awareness and of the role of technical solutions intended to support it.

The Setting

The Swedish language is taught in about 200 universities in 42 countries around the world (except for Africa). Most of the teachers in this group are employed by the respective universities and are either non-Swedes that have a degree in this language or Swedes living in the respective country.

Besides the interest of certain universities in teaching Swedish language and/or culture, the Swedish government has a plan of promoting Swedish language and culture abroad. The vehicle for this promotion is a governmental body called the Swedish Institute (SI). Four persons from SI are involved in this activity. The prime targets of their efforts are the teachers of Swedish abroad but support is also given directly to students.

Our goal was to try to identify if we would find the needed prerequisites for a community of practice and to actively try to sparkle and sustain such a community through action research and technology. Our expectation was that a community of practice in this teachers' group would bring a number of benefits including a better interaction between the members, a strong support for new members of the community and a leaner learning curve for them. We considered that by sharing experiences and information, the best practices would be better disseminated, that 'rework' and 'reinvention of the wheel' will be reduced and that new ideas and solutions would emerge.

We used a number of methods, ranging from interviews, questionnaires, PD workshops, personas workshops, etc. in order to get an understanding of the setting and to explore possible design solutions. These explorations led to a number of findings.

The first finding is that the group is very diverse. For example, as they work in different countries they are faced with different cultures and customs. They have to find ways to deal with those cultures while still being able to do their work in the way in which they are trained. The universities where they teach are also very different in what they require from a teacher as well as in number of students, support that the university provides to the teachers, etc. In some cases the Swedish

courses are compulsory and the teacher has vast resources and support from the university while in other cases these courses are optional and there is (almost) no support or resources.

The people teaching Swedish abroad also have very different backgrounds and motivations. Some have a formal training for the job while others are simply Swedish people that happen to live abroad and are teaching their native language. Some are Swedish and have been trained in Sweden while others are local and learned the language in their native country. As such, skills, methods and experience are at varying levels within the group.

Major differences have also been noted with respect to the relation between the teachers and SI. While some of them have strong formal ties with the Institute, due to the fact that it is SI that employs them and sends them to a certain university, other have only an informal contact based on the fact that SI is happy to provide information, support and encouragement to anyone that teaches Swedish abroad. In certain cases there is almost no contact between teacher and SI, even if they are aware of the existence of each other.

Another area of differences is related to the access to technology and the skills and attitude towards it. In most West-European and US universities computers and the Internet are given elements of modern education. Both teachers and students have easy access from the school as well as from home. In other countries, especially in Eastern Europe and Russia this is not the case. Computers are few and outdated and Internet connection is rather an exception than a rule. Teachers have to rely on their home Internet connection (normally over modem) or on Internet cafés. IT skills and attitude towards these technologies are also at different levels. Some find it rather complicated to handle a computer or to find good information on the net. Others use it a lot and have advanced skills and a very open attitude. Whatever technology we would develop, we would have to keep this in mind when designing it.

While the first impression is that the group is very diverse, we soon started noticing similarities. For obvious reasons, the Swedish language and culture is one major common denominator. Most people in the group are very passionate about them, about teaching them. Our investigations pointed out that they not only teach Swedish but most of them are involved in a number of other activities related to promoting Sweden or the Swedish culture. This can include writing and publishing

locally about Sweden, organizing events, participating in activities of the local Swedish community (where such exists), etc., all of them done on a more or less voluntary basis. Even in classroom activities we could notice that they are “ambassadors” of Swedish culture. That happens because they do not simply teach Swedish but they do it by using Swedish methods, pedagogies and customs. In a number of situations these come in strong contrast to the local culture and by using these “different” methods they provide the students with more than “yet another language”.

In our investigations we noticed that it was difficult for the teachers to talk about their work without mentioning the students all the time. They are not only passive receivers of learning but are active elements of the teachers work and they define the way the teacher plans and acts in the future. It is hard to talk about this group of teachers without continuously keeping in mind the contribution and the role of the students. It is clear that working with them is a joy and a strong motivation for most of the teachers. The interaction with the students is even more important to them than it might be for other teachers, as they have often reported that they ‘feel alone’. After all, they work in a foreign environment, teach a language that is not a major one, and in most cases are the only Swedish teacher at the given university. This makes it hard for them to find someone with whom to exchange information, ideas, opinions or inspiration regarding Swedish teaching. Other things, like pedagogy issues, daily problems, etc. are normally discussed with colleague teachers of other languages (mainly other Nordic or Germanic languages) or with other university staff and colleagues.

When observing work patterns other similarities emerged. First, it can be noted that work is not limited to teaching in class. A lot of time and effort is spent on preparing the courses. It seems that new types of courses need to be prepared all the time, requirements from universities change, number of students or their motivation to learn languages as well. Because of that teachers are always looking for new, better materials to use in class, new methods or new information. It is important for them to find such things, but also to know how these things can be used in class, what works and what does not and why. Even teachers that have a long experience in teaching still need to improve on their courses and still develop new courses.

It is in this process that teachers would normally need most contact with other teachers. They can discuss different experiences, point out to each other new available materials or methods and get inspiration from each other. In our case, because of geographical isolation, such discussions are impossible to have or are limited to very few other teachers.

Trying to conclude our findings we can say that we have a group of people with similar interests but with no real community. People know to a small degree each other but not all. This is caused by the fact that they seldom meet and then only in small groups (20-30 people). Communication is limited to a small number of people that keep in touch with 2-3 other teachers they met somewhere. No special IT support tool, except the common email, is used for communication. In the same time we noticed a strong need to communicate with each other, to share problems and experiences, to have someone to turn for a solution or advice, etc. In the community literature this is called an “incipient community”.

Another aspect of our findings was the role of SI for the different teachers. While for a part of the teachers the SI was a clear employer, and as such that part of the group had a canonical relation to the support team, in other cases the relation was one of equal partners, with experienced teachers abroad being in active contact with them, getting help but also providing information and support to SI or to other teachers. Yet in other cases, while no official canonical relation was present between the SI and the teachers, a certain form of authority was attributed by these teachers to the SI, which was inhibiting sometimes communication or making it more formal than needed. This mixture of formal and informal relations made the group an even more complex case, especially in terms of finding a technology that could fold itself into this diversity of social norms and realities.

Prototype

When discussing the technology that could be used, we understood that the very heterogeneous conditions that teachers had would force us to use only technology that would be rather basic and simple, as any more advanced technology could either not be deployed out of cost and time constraints or would be too technical for certain teachers and would probably not work because of lack of technical infrastructure in certain places. We envisioned a community web space, in line with similar

technologies. What we were interested in was to create a design that was properly tailored to the needs of our group of teachers. The first version was focused on two functionalities: a Forum and a Teaching Material Review system. Both of these functionalities are part of the outcome of the participatory design workshop, in which teachers discussed what they would like to do together in an online community.

THE FORUM. The members of the group repeatedly expressed the wish to have an online forum. It is considered a very important element of any such community web site as it provides a simple communication method, one that most are used to. At the same time users agreed that this would not be enough for a community to unfold but it was considered central. We decided to implement a forum with clear features: simple ways to search for existing messages or to contribute, etc.

TEACHING MATERIAL REVIEW. During the workshop there was a clearly expressed interest in providing the teachers with a system that would allow them to find teaching material. The most important feature they asked for was a way to comment on the materials so that they could rely on each other's advice in using the materials.

It came across all interviews and questionnaires that the teachers are in a constant "look-out" for new, better, materials for use during classes. As such, teachers rely on the opinion of other teachers. That is exactly what they would like this system to do for them; help them find the material and then provide information on how others have used it and with what result.

In order to increase interaction, awareness information about who is currently online should be provided. First of all, each user had a profile page where each can enter contact information, name and university where they teach as well as any information about themselves that they consider of relevance to the others. The system would also show on each page the number of users that are connected to the site in the same time as well as link to a list of those users.

Because we understood the very hectic nature of a workday for teachers, and knowing that time allocated in front of the computer was minimal, we tried to create a first page that would allow a very fast, but relevant, glance of what is new in SvenskWebb (Figure 4.5). The first page was designed to provide two major functions: to show the functionality available on the site in a simple, clear way and to show the most

important changes since the last visit, providing in this was a *glance view* to the users. While the first characteristic is important especially in the beginning, the second is of great help for people that do not have too much time to spend on this. Our goal was to allow with a single page visit a clear image of what is new and hopefully to wake interest in further explorations of the site.

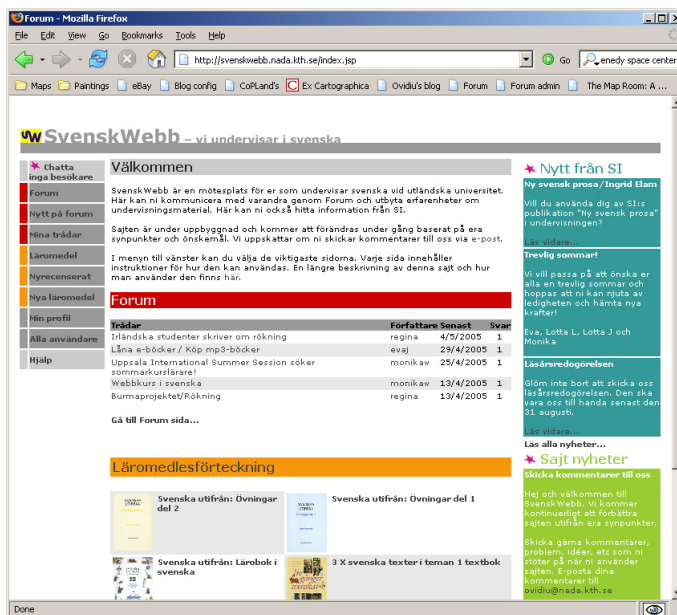


Figure 4.5 Svenskwebb - First page as glance view.

Regarding the launch, we knew that the site by itself would be of no major interest to the teachers, at least not until there was some interesting content. We decided that the best thing to do would be to provide a number of teaching materials, in our case, book descriptions imported from a leading Swedish academic bookshop's web site. This bookshop and SI have a long-standing cooperation in which they produce a special catalogue of those books that are useful in teaching Swedish as a second language. It was exactly this catalogue that we imported on our web site, offering the possibility to the teachers to rate and review these books.

Use and Evaluation

After all the technical preparations, we started the site and had been running it actively for about six months. The site had been up and running further on but without intervention or monitoring from our side. The use discussed here refers mainly to those initial six months.

More than 150 teachers registered in the first couple of months, the final total being at about 350 users. Most of them started by checking the site 2-3 times a week in the beginning while this rhythm reduced to once a week or 2-3 per month for most of the users. About 20 of the users became not only visitors but also contributors with messages in the Forum.

The members of the SI team were of course very active in posting and in adding information to the site: the latest news regarding books, seminars, summer schools or new employment opportunities. In fact they decided to shut down an older news system on their official site that had proven not to be used by the teachers any longer.

In these first weeks we noticed that the first things people did was to enter information in their profiles, to check out the profiles of the others and to check from time to time who else has registered. As we had no page that would list all registered users, we added one where those that registered since the last visit are highlighted.

A number of people also started to use the forum and to suggest common projects of smaller scale. We started seeing other teachers responding and contributing to those small projects. In the same time, as they started using the site, the users began sending us requests for improvements or for new functionality. That was exactly what we were looking for. They wanted, for example, to be able to add images to the messages (including uploading those images). Or in another instance they wanted a simple chat system so that they could discuss with each other if simultaneously online. We gladly provided these new functions and improvements.

When asked about what they had expected from this web site, it seems that most had a clear picture of what such a site could be for them: a place to 'meet' other teachers, a place where information and ideas would be exchanged, etc.

“An interesting forum that can grow, if we get involved”, “I was planning to use it for exchange of ideas and [teaching] materials”, “I expected contact with other teachers, tips about teaching, tips about web sites with information”

While most answers suggest some sort of interactive place for the teachers, others expected a place full of information, probably expecting less active involvement for the members: “I wanted to find suggestions for lessons”, “I was hoping to find a site with ideas about books...”

After some months, contributions did not grow in number and it turned out that the same 5-6 teachers tried to use the site more actively. While the Forum did have a certain success, we also noticed that nobody used the Material Review part, except for looking for materials. But no review has been introduced and as such the concept of the part proved to be somehow wrong. People also reported why they would not access the site more often. Two reasons have come up in a relevant number of questionnaires: lack of easy internet access and lack of time. Regarding the last one, one teacher wrote: “To check out something on the internet, something that I don’t necessarily need, is always at the bottom of my [priority] list.”

After these initial six month, the site has basically run out of steam in terms of activity and, as our project was coming to a conclusion, we could not allocate the resources needed to continue to encourage this group of people any longer. Since then, while the site is up and running, only occasional messages are posted.

During this first part of the project we have learned a number of lessons. First, working in a cooperative way with users that are geographically distributed is an additional challenge to such a project. While we were hoping to use methods that we are familiar with, we soon understood that we would need to change and adapt those methods to the distributed setting.

This led to the decision that the best way to move forward was a fast prototype that would allow us to initiate a community place and would allow the users to contribute by having a given technology in use. As soon as that happened, the users started expressing wishes and problems and started forming their new online “space”. The site also provided a starting challenge for this incipient community and we were hoping it would make the teachers gather around it.

One of the most surprising aspects of the use of the site was that the most asked for functionality, that of Material Review, was not used at all. We had provided a relevant list of books in the system, books we know teachers used in their teaching. We also knew from the seminars that the teachers had strong views on the quality and best way of using some of these books. But for some reason, these strong views were never transformed in reviews on the Svenskwebb site.

On the other hand, users did put serious efforts in describing themselves and their activities in detail. This is probably not very different from the motivation we identified in @work, where the need to present one's own activity has been the driving force for introducing information. Retrospectively we can say that we failed in this case to identify this motivation and we missed the opportunity to consider it in the design of the site.

Looking back we would have reconsidered one of the major design decisions: that of not involving the students. One could argue that if we would have done that we would have had a much bigger number of potential active members, 4.000 students compared to just about 200 teachers. We would also have had people that are more confident with new technology and people that have more time to spend in front of the computer. Last but not least, young people might have brought in additional enthusiasm and a bigger number of ideas. Still, at that time, as we wanted teachers to share experiences, information and knowledge, it seemed correct to create a system where our target group would feel unrestrained in communicating with each other.

Looking at the statistics we also noticed that while a good number of teachers registered, most of them would only access the site to view information and not to contribute. This could be attributed to the fact that previously they were used only to receive information from SI and not to contribute themselves. This unidirectional type of communication, traditional in certain cultures, was clearly present in the communication between SI and some of the teachers. We, designers together with the team at SI, would have needed to be more active in properly informing, explaining and suggesting the paradigm shift that the system tried to bring: moving from this formal SI-to-teacher communication to an informal teacher-to-teacher sharing of problems, solutions and ideas.

Another cause for the limited teacher contribution rests with the larger social context in which these teachers are active. While we had used various ways to get a good insight into this, the fact that we could not interact with the users to a reasonable degree, due to geographical and financial constraints, surely brought us to a situation where we missed relevant factors of motivation or the existence of certain social inhibitors in relation to being active in such informal types of structures.

4.3. Ajmo Splite!

Technology has often been utilized to address the needs of specific communities, especially those that are geographically distributed. Understanding how technology could be incorporated into solutions for a traditional local community is an interesting design challenge. This section describes how interaction design practitioners from nine different countries tried to meet such a challenge in efforts to help the residents of Split, Croatia enter into a dialogue with their local authorities about how to develop sustainable tourism within the specific socio-political constraints of their region. The project has been developed under a two weeks period of time during the Convivio Interaction Design Summer School 2004.

We will briefly present this project here as it shows another way of using interactive systems for supporting communities. In this case our goal was to spark social and political awareness for the citizens of Split regarding important issues of the community. This project will help us in the final chapter to compare previously visited settings with this one and to discuss how CSCW can help by mean of social awareness.

The Setting

Split is one of the most important cities of Croatia, located on the Adriatic Sea. Its most important source of income and development is the local tourism, based on the city, which includes the Diocletian Palace, the seaside next to the city as well as the archipelago located in the area of Split.

Based on a number of explorative activities, including tours of the city with a local as a guide, interviews with locals and tourists, field observations and brainstorming sessions, we came soon to the conclusion that the real place where we could help was related to developing some technology for the citizens of Split. This was based on

the fact that tourists did not mention special problems with enjoying their vacations, but on the other hand, local residents were not happy about how politicians made decisions about new planning developments. The peoples' view was that there was no straightforward way of making their voices heard about local planning issues. Also, the planning process itself was seen as flawed and difficult, with one of the interviewees commenting that they had given up trying to get the required permits and just went ahead and built their house.

The Concept

Our design tried to address three major problem areas that we had discovered: (1) lack of involvement of locals in the urban planning process, (2) lack of professional communication tools between community leaders and city planners and (3) lack of acknowledgement of the interest that children might have in city planning issues.

The resulting concept is presented in Figure 4.6. For the second issue we suggested the use of specially developed software, for example the UrbanSim project from the University of Washington (www.urbansim.org). As described on their website, "...UrbanSim is a software-based simulation model for integrated planning and analysis of urban development, incorporating the interactions between land use, transportation, and public policy. It is intended for use by Metropolitan Planning Organizations and others needing to interface existing travel models with new land use forecasting and analysis capabilities."

For the first problem we noticed, the limited engagement of average citizens in issues related to the city's future, we decided that we would need to create a system that would allow them to simply make their views visible to the other people and especially to the local administration. It should consider the socio-political environment and it should somehow spark interest in the urban planning issues. Additionally, such technology was to be chosen that would allow for simple interaction for as many people as possible. In order to improve accessibility to the system, a multiple interface was to be considered.

We also wanted to do an event in the town to get reactions and feedback from the locals as amongst other things, the local habit is to be out in the streets to meet and discuss. The main goal for our prototype was to create an initial spark, which would get people talking and interacting with the political machine. We also wanted to include some notions from

Interaction design (i.e. that a design should be fun, engaging etc.), especially since we wanted to include children in the interaction.

The design focused on building a single digital billboard that afforded different types of interaction and offered local people, of all ages, a platform to voice an opinion on a local issue. From our conceptual drawings a prototype design emerged. This design centred on a kiosk being placed in a public space in the city, with people's opinions being projected onto a wall.

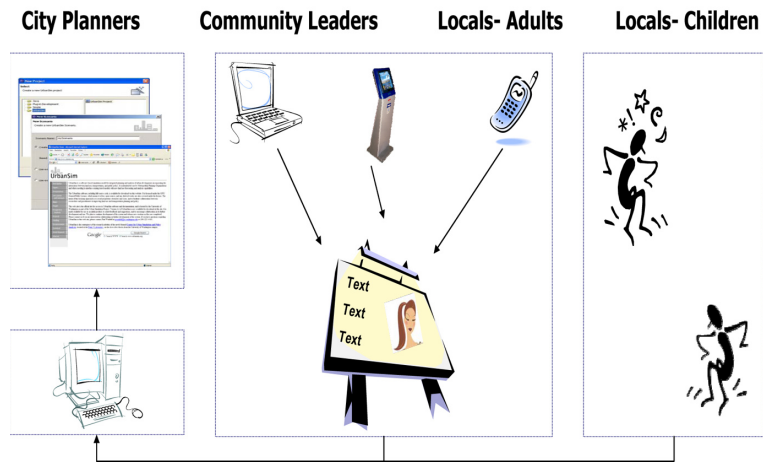


Figure 4.6 The three concepts integrated into one.

The prototype that evolved from our conceptual discussions was a three-sided kiosk. This kiosk served several functions (i) to provide information to locals about the project and the summer school; (ii) to capture video clips of people responding to the question 'How well is planning and control organized in Split?'; and (iii) to provide a physical and more playful interface that allowed children to voice an opinion on a related issue. Each of these functions was allocated a side in the kiosk design. In addition the kiosk contained some of the technology that was required and provided a platform for the projector.

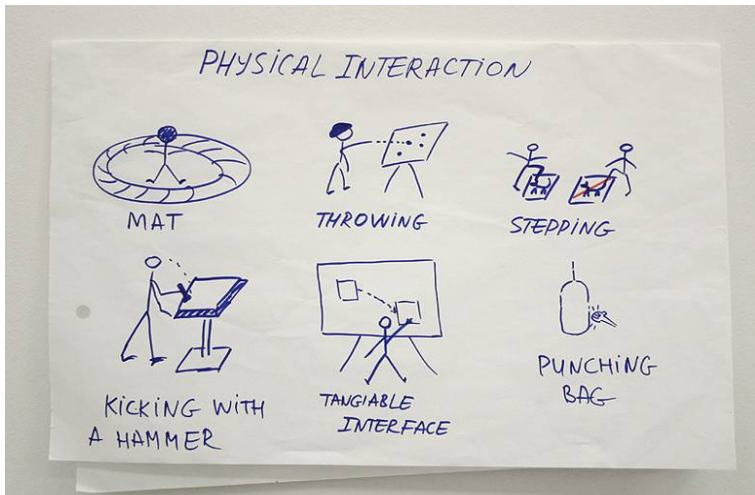


Figure 4.7 Concepts for Children's interaction with the Prototype.

A webcam enclosed in one side of the kiosk allowed users to record 15-second clips by pressing a button and speaking into the camera. A mirror around the camera provided the users with visual feedback on what was being recorded.

The children's interface was originally intended to encourage a more physical and playful form of interaction (see Figure 4.7). It was agreed that this was a more intuitive and natural way for children to express themselves. Also, other researchers have claimed that the use of traditional human computer interaction styles with input devices such as a keyboard, mouse, or game pad are not interactive enough and encourage poor interaction. They propose that researchers should explore more physically engaging alternatives (Höysniemi et al. 2005). Given all this information we decided to develop a more 'low-tech' alternative that met our design goals and would prove to be, we hoped, physically engaging. Two illustrations were attached to one side of the kiosk, each a response to a single issue. Children were able to voice their opinion by simply throwing a soft ball into one of the paper baskets fixed below each illustration.

The Trial

Preparing the test of our prototype meant finding a proper location. We finally chose Fruit Square, a square in the centre of the city that was

surrounded by cafes and bars. This square was a popular place for people to socialize and also formed part of a through way between the medieval city and the promenade. It was decided that we would run the event in the early evening, when families were out in the city enjoying their time.

The kiosk was placed in a public space (Figure 4.8) with content being projected on to one side of a medieval building, a seamless mix of new and old. People could record video clips of themselves or could SMS their opinions to us.

The projection combined information about the project together with captured video clips and text messages. New content was interspersed with random selections from previously captured content. A local, wireless network was set up between three laptops. Collectively these laptops captured, stored and projected people's opinions on to the wall. Technically the prototype combined both automated and 'Wizard of Oz' approaches. Whilst video capture and selection was automated the handling of text messages was more 'hands on'. This was a conscious decision that was made earlier in the design process. It was decided that given the public setting text messages should be checked before being projected. Consequently text messages were received, checked, edited if necessary, and then forwarded for projection.



Figure 4.8 The event in Fruit Square.

We succeeded in sparking interest among the citizens. They stopped and followed the messages that were displayed; we received live SMS messages (9) during the short time of the event; a small number of video messages were created (6) and we succeeded in giving a voice to the kids. In fact the kids were the most interactive participants in our installation. We noticed that kids were drawn to the simple physical interaction, where they could easily express themselves regarding the two illustrations.

SMS seemed a more acceptable technology than video messaging, this is probably for two reasons, firstly, the fact that people are used to sending SMS messages to each other or to TV shows but are less comfortable with leaving a video message. Secondly, anonymity could also have been an important factor here.

During the set-up of the kiosk and the preparations in the square, a large number of people came forward and started asking questions about what we were doing, about the technology, etc. As we finished the setting up of the prototype, all the technology disappeared inside the prism that we had constructed so that in the end a clean, simple structure was standing in the middle of the square. We had decided that the technology should be hidden away so that it would not 'scare people off'.

To our surprise, this worked against us. As soon as the technology was hidden away the interest for our installation reduced dramatically. This finding goes against some common ideas in interaction design, where it is often suggested that it is best when technology disappears and becomes invisible.

Implications for Design

Looking back at this small but very intense project, there are some lessons to be noted. Firstly, the project showed that when talking about digital technologies and communities we should not only think about virtual ones. Real local communities might need help for communicating to the same degree as virtual ones. The modern society, with its bigger and bigger urban areas transforms the individual to an invisible part of the fabric of the society, or so it feels at times for the people. Using technology could be one of the ways to improve the value of the individual voice and approaching such technologies in a people-centred way is desirable as a good way to locate and understand where the problems are and how, if at all, technology can help to solve them.

While other technologies for communities attempt to move the debate about 'the city' into the virtual realm, via online forums, mailing-lists or VR models of physical spaces, our approach went in the other direction, that is, moving the democratic discussion back where it once started: the Agora or forum of the city. This is especially interesting in a place like Split, where most people do not have easy access to computers or to the internet but the local custom is to be often out in the city centre and to meet friends, relatives and neighbours and to talk 'politics'. With a technology, as the one suggested here, all that 'talk' could be transformed into a stronger political stance for the people of Split.

The design process that we went through also provides interesting raw material for reflection. Maybe the most important finding was that even in a very limited time frame a people-centred process could be applied with very good results. The claims that involving the user in the design requires a lot of extra time and extra resources should be reconsidered. This project proves that if one is determined to properly consider the user in the design of new technology, time and resource limitations are not valid excuses for not doing it. Obviously we felt limited by those constraints and while we would have wanted to have deeper user involvement in the process we still succeeded to find methods that were user-centred and that fitted into the time span of our project.

Even with these given constraints, using user-focused methods has paid dividends. After a very short investigation and a small number of interviews our findings forced us to reconsider the assumptions that we had in the beginning. If we would not have started with 'listening to the user' from the very early stages we would have lost precious time on developing a concept and maybe even a prototype for a problem that was never there. Our design intuition had let us down in the beginning but we were soon back on track thanks to the information gathered from the real world. Repeatedly going back to the local people, be it random people on the street or community leaders that we had previously met, has helped us adjust the concept and the design of the prototype in every step. Under normal circumstances we would have done that in a more elaborate way, probably by arranging some participatory design workshops but as that was not possible we used whatever opportunity we had to talk to people about our understanding of their socio-political environment, the local rules and habits and about our design. Listening to their reactions and taking those into consideration has been a major part of the project.

Of interest is also our choice of developing a high fidelity prototype as that goes against accepted wisdom. We feel that by using such a solution we were forced to do much more than a paper prototype (or similar) would have allowed for. For example, we had to properly prepare for the event as it was to be [almost] the real thing. This led us to think about and plan for 'the work to make it work' (Bowers 1995b). In doing that we had to better understand the local setting, the customs as well as the official regulations. Having gone through that process we can say that we achieved a better understanding of our target group and of their environment than we would have gotten otherwise. We feel that making the decision to have a hi-tech prototype was the right one as the working technological solution made people interact and it gave them, and us, a deeper understanding of how interaction can be achieved. Paper or other low-tech prototypes would never have achieved the same response and fascination from the citizens. However, some parts of the prototype were low-tech, for example, the baskets and balls together with the illustrations for the kids voting. If we had had more time we would have undertaken some participatory design workshops with locals around the prototype concept.

The decision to go for a hi-fi prototype has also shown that a lot of 'ready-to-use' technologies are out there and that putting together a number of such technologies is a matter of hours, not weeks or months. In a sense one could reconsider a bit the initial thought regarding low-fi prototypes. Since then technology, both hardware and software, has moved ahead and a lot of time 'off-the-shelf' solutions can provide good, flexible components for prototyping. The argument that working prototypes can 'lock' designers into early solutions which might not be the proper ones has less weight as replacing certain components in a solution or starting again from scratch will not mean wasting a lot of time and resources anymore. The advantage on the other side is that a working prototype will hopefully create reactions closer to the future use of the proposed technology.

The working prototype and the time constraint forced us to use methods and techniques that resemble recently introduced principles of software design like 'agile' or 'extreme' programming. Thinking retrospectively, the whole design process that we went through in those two weeks had strong 'agile' and 'extreme' characteristics.

This brings us to a smaller yet surprising finding relates to the role of technology in such a project. Going with the ‘traditional’ wisdom of HCI where ‘the disappearing computer’ has been preached for a number of years, we decided that our prototype should hide whatever technology was making it work. Nothing but a button for starting the video recording was visible and even the feedback for the recording was done with a simple mirror. While this created a clear, simple interface, when we tested our prototype we found an interesting fact. While we were setting up the prototype, the computers were visible as were meters of cables, mouse, keyboards, etc. This attracted people who came forward and started asking questions. Once the prototype was set up and the computers had ‘disappeared’, the attraction value of our kiosk diminished; fewer people stopped by to ask questions. This prompts for a small reconsideration in regard to the visibility of the technology. We would say that given the goal of our design, that of sparking interest and creating reactions, technology should have been left on the outside as it would have drawn people’s curiosity. The rule of the ‘disappearing’ computer has to be considered in each design project correctly in relation to the goals that are to be obtained.

To conclude, small, time-constrained projects can be done in a people-centred way even if methods need to be carefully chosen and sometimes simplified. Still, going after the needs of the user proves to be beneficial even in such situations and, as such, project constraints should not be used as arguments or excuses of not trying to better understand the user’s needs by directly talking to, observing or involving the user. Additionally the project provided a couple of interesting insights that other design projects might care to consider in their approaches.

4.4. Discussion and Conclusion

In this Chapter we presented three design-oriented project in which our focus was supporting communities with interactive systems. In the cases of Saxaren and Svenskwebb the intention was to find ways of improving the knowledge transfer between these geographically dispersed professionals. In Ajmo Splite! the goal was to see how digital technologies could help even traditional communities like that of a city.

Role of Social Awareness in the Settings

Interesting for our investigation is to see how social awareness in particular, and awareness in general has played a role in these settings and in the design process we undertook in each of these projects.

In Saxaren our findings pointed out that the archipelago teachers were forming a group that had all the major prerequisites to form a community of practice, one governed by non-canonical rules, even if they all belonged also to a clearly established organization. What was lacking was a higher degree of social awareness to stimulate social interaction, and there we considered that we could try to bring improvements. Based on this we realised that the key role of the suggested technology in this setting was not to directly support knowledge transfer but to support the forming of one of the important ingredients needed for a community of practice, a proven vehicle of knowledge transfer: social awareness.

Our goal became the integrating social awareness in the day-by-day environment of the teachers, in a way that was simple, intuitive and ubiquitous. The results of our study show that it was not the use of the Saxaren for work related issues that proved to be its strength but the social interaction that has led to better social awareness. This improved social awareness has in its turn improved work related communication, as we targeted.

In Svenskwebb we identified partly similar characteristics of the group. Both projects addressed two groups of geographically distributed teachers, members of both groups were keen to share more ideas with the other teachers, most of the targeted users seemed genuinely passionate about teaching. All of them shared the same 'nomadic' type of work life, with little time for new tasks or activities, with limited time spent in front of the computer, etc.

Probably the major difference was the social context present in the two groups. In the case of the archipelago, all teachers shared the same culture, the Swedish one, and the same subculture, that of the archipelago, a 'rural' type of culture. Sweden, among other things, has a culture that encourages informal type of relations at work, the boss being just another colleague, for example. This inherited openness towards informality has surely played a key role especially in the initial stages of use of the Saxaren. Users felt free to experiment, to try, to fail, to be

misinterpreted, all that because their culture not only tolerates such actions but encourages and rewards them.

Saxaren also shows that digital solutions can be considered not only for virtual communities, an area with already strong experience and traditions, but also in 'real-world' communities or groups, as in our case. For them IT-based solutions can complement existing communication channels, as long as the suggested technology covers the types of communication that are not supported by existing channels. In our case it was the informal, spontaneous, fast, social communication that was targeted as we found that only formal communication was supported by the communication means of the teachers.

Ajmo Splite! addressed also a traditional local community where one would not expect to see digital technology at use in sparking and improving social and political awareness in a place where organized structures exist. Still, we have shown that technology can be used as a playful, attractive, innovative way to raise awareness to the issues of the community and to provide more direct communication of ideas within the community.

Role of Play in Social Awareness

In Saxaren, of relevance for the build-up of social awareness was the playful nature of the communication. Encouraging this sort of interaction, in a work-oriented environment, might seem less natural but designers cannot ignore the social nature of people and playfulness can be constructively and creatively used in order to achieve a better work-related collaboration.

Here the technology is redefined from the role of a cold handler of information and knowledge into the role of being a social and emotional catalyst. In taking such a stand, technology designers acknowledge the social and human nature of work. Thus, doing something fun and playful can be a way to support and improve social awareness. This is not new for work-related practices where team-building and similar activities try to develop the playful, fun, social nature of teams. It is only in the area of technology development for work situations where this part is normally ignored, probably out of fear that it would be a 'unserious' approach to improved social awareness, a better social context and a higher level of communication between members of formal structures or informal communities.

Thus, in Saxaren we discovered that one can renounce relying on the formal or informal norms or expectations and instead can provide a tool that would encourage new ways of interaction that are fun and interesting, this becoming the major motivation for use. This comes in contrast to our approach in @work, where the motivating factor for using the system was the work-related need of presenting the work, publications, and other information about oneself, as well as the understood informal obligation of providing the others with clues of ones whereabouts.

The playful, novel and exciting way of interacting with our system was also the vehicle of motivation for citizens to get involved in our Ajmo Split! project. As we have seen, technology out in the open can trigger curiosity and interest that can be then channelled towards involvement and participation, exactly what was needed in this project for raising the local awareness.

Translucency

The type of medium that Saxaren provided, with its richness, allowed the users to make ample use of their advanced skills of handling social awareness information. People are well equipped to select relevant information that would need to be communicated to the others, understand how to use a medium for transmitting that information and, at the other end, have the ability to infer from the received information what is relevant, what needs to be remembered for potential future use.

Our Saxaren is such a 'translucent', 'transparent' technology (Dourish and Button 1998) where we did not try to encode in the technology the social norms or the handling of awareness information. Rather the opposite, in line with the overall Participatory Design philosophy, we used an approach that keeps the technology-coded functionality to a minimum in order to allow for the human social skills of the users to define and refine the way in which the system should be used. Any later change or added functionality was done only with the goal of supporting this natural communication and not in order to 'procedurize' communication, as most of the communication and collaboration systems try to do.

Translucent is an attribute that can be applied also to the Ajmo Split! prototype. There, the interactive kiosk allowed for simple collection of video or text messages and simple display in a very public location. The

system did not interfere with the messages, nor did it select the relevant ones. All messages got displayed in a random way, by this allowing all points of view to be seen.

Real-Life Awareness Characteristics in the Settings

Considering the way in which social awareness is supported in Saxaren and how it worked in our case, we can compare the characteristics of real-life awareness, as presented in the Introduction, with the solution that came together in our project.

Firstly, if we look at the time and space considerations, we clearly addressed a situation where the major gap that needed to be bridged was that of space. It was the distributed nature of the group at hand that was the cause of the initial difficulties that our system tried to resolve.

Regarding the time aspect, in Saxaren, while the teachers work more or less in the same time interval of the day and on the same days, still, the very nature of their work, with constant movement between classroom, teachers' office and home, would have made any synchronous communication solution, like video feeds, of limited use. As such, the technology that proved to work was asynchronous and allowed for interaction in those short moments when people could be available for it. This is, in the case of the teachers, a very relevant aspect. As identified also by Bogdan et al. (2006), the workday habits of teachers are 'nomadic', because of the fragmentation of work and presence both in space and in time. In such a situation, social awareness of the others becomes key to encouraging communication and knowledge exchange with the others.

In Svenskwebb we could identify the same pattern and while the first goal of the technology was to bridge space, it was observed that synchronous communication tools would not have helped, given the 'nomadic' daily activity of teachers. At the end the technology had to cater for both the bridging of space as well as time.

The real-life characteristics of awareness, that of being a regular, repeated monitoring activity (Heath and Luff 1992), done as a peripheral task and not as a conscious, dedicated task, has been the centre of our design focus. A number of design considerations addressed this characteristic.

For example, in Saxaren, the placing of the whiteboards was intended to make the 'regular monitoring' possible. The specifics of the workday of

teachers, the permanent movement between locations (classrooms, teachers' room, etc.) makes regular monitoring impossible, but our solution provided them as often as possible with opportunities for a simple glance and so a monitoring of the communication with the other units. The positioning of the board as well as the simple interface, designed so that a fast glance view would be enough to perceive any addition to the Saxaren allows the users to follow the system in a peripheral way, without the need for any explicit action or for any advanced planning. It is enough to pass by and to have a short glance.

In Svenskwebb, we could provide the users with the glance view, similar to those in other projects. Unfortunately, due to the various limitations of this setting, as detailed above, we could not provide a similar 'presence' of the interactive system in the physical space of the teachers abroad. This has led to the fact that checking the Svenskwebb was not something teachers could do on the go or while doing something else. Instead planning, time and effort was required, something that went against the real-life way of handling awareness, and as such, became an inhibitor to using the system.

Use of Methods

All these projects have been using, especially in the exploration and design part, Participatory Design (PD) methods. In Saxaren user involvement was also useful in later stages of the project. We successfully involved the users also in the deployment phase, a phase that often is being considered trivial while it does tend not to be. In our case, the teachers helped us find those locations that provided for the most convenient interaction.

User involvement in the deployment phase also allowed for a simple solution to the privacy control issue. It proved to be enough to *reuse the privacy affordance* of the physical space by properly positioning the whiteboards in locations that already had privacy rules in place. This allowed us to keep the design of the Saxaren simple as we could leave out from the system the privacy control mechanism. By doing this, our system could be always on, instantly usable and a very good tool for informal communication.

In the case of Svenskwebb, applying user-centred methods was not obvious as access to these users was very limited. We decided to use an indirect approach, not very different from the triangulation used in

topographical surveys: "when a certain point cannot be measured directly, an indirect point is being measured". In our case we could not meet and involve the teachers in the way we wanted. But we understood that the team at SI has deep knowledge of the life and work of our future users. As we had easy access to the SI team, we involved them in our design workshops and used their practical, first hand experience and understanding instead of the experience and understanding of the teachers.

This type of triangulation is not the same as the type, where different methods are used to understand the same users in a direct way. In that case the different methods are used to complement each others' findings. In our case we are talking about a triangulation where we could not work directly with our users so we had to work with those people that had the best knowledge about the targeted users. Those findings were, of course, complemented by the methods that we could use in direct relation to the teachers, like questionnaires, interviews, etc.

In Ajmo Split!, even if the project was done in less than two weeks, we insisted on using user-centred methods. While we had to adapt and simplify them, nevertheless we tried to interact with people of Split as often as possible, in the exploration part of the process as well as in the design and deployment phase. The positive results of using PD approaches, even in a reduced form, have been shown in the section describing this project.

Conclusion

This chapter presented three design-oriented projects conducted in community settings. We have looked here especially at the social awareness issues and at how we have tried to solve them in each specific case. The discussion highlighted the most relevant findings in those settings.

We have seen that social awareness can play a key role in enabling communities of practice and we have discussed how technologies can support this role in different settings, both in geographically distributed and in traditional local communities.

We have also found that play, exploration and fun can be useful in developing social awareness even in work-related environments, as seen in Saxaren, and technologies should try to provide the needed "playground" for such social activities.

We have shown that translucent technologies are valid alternatives of design for improved social awareness, especially if we have in mind the relation we found between play and social awareness.

We have discussed also the way in which real-life awareness characteristics have found relations in the design of the interactive systems that we proposed.

By this the chapter contributes to a better understanding of the research questions of this thesis, while a number of the findings and interpretations of this chapter will be place in the broader discussion found in the final chapter of this thesis.

5. Aether

- An Awareness Model

The work done around social awareness, as seen in the design-oriented projects presented in the previous chapters, inspired us to consider the possibility of creating a theoretical model that could be used for addressing awareness issues at a system level in interactive systems of a collaborative nature.

This model, called 'Aether', is, arguably, the most important contribution of this thesis. The present Chapter will introduce the theoretical model, as well as a number of other theoretical extensions to it. We will also address here the theoretical *implications* of the proposed model.

In order to validate the model, we present in the following Chapter, a number of *applications* of the model, as well as some further ideas on how the model can be used to address both a number of awareness-related aspects as well as other problems in related areas, for example, 3D environments.

5.1. Introduction⁴

Extending and reinterpreting earlier work on the 'Spatial Model', this chapter presents a generic model for supporting awareness in cooperative systems ('the Aether model') and an implementation of a prototype awareness engine. The chapter closes with a discussion of how the model facilitates the construction of flexible CSCW systems (e.g. workflow systems) supporting a variety of forms of awareness.

⁴ Sections 5.1 and 5.2 are a reformatted version of the first part of Sandor, O., Bogdan, C. and Bowers, J.: "Aether: An Awareness Engine for CSCW", in Proceedings of the Fifth European Conference on Computer Supported Cooperative Work (ECSCW'97), Kluwer Academic Publishers, 1997.

The topic of awareness has received a great deal of attention in research work in Computer Supported Cooperative Work (CSCW). For many researchers, providing participants with mutual awareness of each other's activities is seen as an important research and design goal (e.g. Dourish and Bellotti 1992; Tollmar et al. 1996). The emphasis of much of this research is to provide an alternative way of supporting cooperative work to that found in, for example, workflow systems (e.g. Glance et al. 1996), where work activities are given a formal representation in terms of some workflow model which often stipulates how the contributions of different participants in a cooperative endeavour are to be coordinated.

In contrast, in many awareness-oriented systems, the coordination between different activities is supported by giving participants an awareness of what each other are doing or have done so that participants can coordinate their work themselves. Many researchers hope that, not only does this provide a 'truer' and more 'lightweight' sense for 'support', but also make for more flexible applications, which are not liable to the usability criticisms (cf. Bowers et al. 1995) that can be made of more procedural-oriented approaches to CSCW.

Some versions of these arguments can be found in the literature on 'media spaces', where audio-video technologies are used to provide awareness of activity at a remote site or in other office spaces (Gaver 1992), but perhaps they find their most detailed elaboration in work on Collaborative Virtual Environments (CVEs), where Virtual Reality (VR) technology is used to support cooperative applications, such as virtual conferencing or collaborative information visualization and retrieval. Most notably, the COMIC project (COMIC 1993; 1994) offered a 'Spatial Model' of interaction in shared virtual environments (Benford et al. 1994, 1995), which has provided the basis of a number of experimental applications as well as influencing the fundamental architecture of at least two VR systems: Dive (Carlsson and Hagsand 1992) and Massive (Greenhalgh and Benford 1996). The question arises, however, of how this research theme is to be further advanced as a major constituent of CSCW endeavour.

We would like to argue that some of the most promising work currently on the theme of awareness in CSCW is concerned with one or both of two issues. Firstly, there exist attempts to integrate support for awareness at fundamental levels of cooperative system architecture. We have already mentioned how the Dive and Massive virtual reality systems

implement awareness-oriented notions. Trevor et al. (1994) report on how a shared object service can be designed to facilitate user's awareness to the state of and changes in shared objects. Further attempts to 'build in' awareness as a foundational feature of cooperative systems are likely to be seen. Secondly, some of the concepts, models and notations elaborated in the development of awareness-oriented applications and systems will be found to have a broader utility. As an example of this, see Rodden's (1996) work showing how support for awareness can be added to workflow, shared databases and other cooperative systems.

In this chapter, we attempt to address both these issues. First we show how concepts derived from the COMIC Spatial Model (Benford et al. 1994, 1995) can be reinterpreted to have general utility beyond the domain of shared virtual environments, which was their initial application. We present the way we use the model and the new concepts we introduce. We describe the current implementation of an awareness engine, called Aether (Awareness Engine Theory and Experimental Realization), and based on the suggested model, our goal is to recognise awareness at a fundamental system level and to build other functions on top of it.

The Spatial Model

As the Spatial Model, largely developed in the European Communities' COMIC project (1992-1995), forms the basis for our work, we will spend a little time describing its essential elements. The Spatial Model supposes that objects (which might represent people, information or other computer artefacts) can be regarded as situated and manipulable in some space. The notion of 'space' is very generally conceived only subject to the constraint that well-defined metrics for measuring position and orientation across a set of dimensions can be found. In principle, any application where objects can be regarded as distributed along dimensions, such that their position and orientation can be measurably determined, is amenable to analysis in terms of the Spatial Model, though cooperative VR applications provide the most obvious examples.

The interaction between objects in space is mediated through the relationships obtained between three subspaces: aura, focus and nimbus. It is assumed that an object will carry with it an aura which, when it sufficiently intersects with the aura of another object, will make it possible for interaction between the objects to take place. On this view,

an aura intersection is the pre-condition of further interaction. For objects whose auras intersect, further computations are carried out to determine the awareness levels the objects have of each other. The subspaces of focus and nimbus are intended as representing the spatial extent of an object's 'attention' and its 'presence'. Thus, "if you are an object in space, a simple formulation might be: the more an object is within your focus, the more aware you are of it; the more an object is within your nimbus, the more aware it is of you." and accordingly, "given that interaction has first been enabled through aura collision: The level of awareness that object A has of object B in medium M is some function of A's focus in M and B's nimbus in M." (Benford et al. 1994)

It is important to note that in the above definition, awareness-levels are defined per medium. Thus, the 'shape' and 'size' of each of the aura, focus and nimbus subspaces can be different, for example, in the visual (graphical) than in the audio-medium. In this way, I may be aware of the sounds made by another object, but without being able to see it. Benford et al. (1994, 1996) go on to show how simple instantiations of this model can have a high degree of expressive power, for example, enabling one to distinguish between different intuitively familiar 'modes of mutual awareness' on the basis of the possible relationships between A's awareness of B and B's awareness of A. However, perhaps the most important point emphasized in this work is the insistence that awareness is a joint-product of how I direct my attention to you (focus) and how you project your presence or activity to me (nimbus). Applications that recognize only one of these two components may well be experienced as too intrusive or too inflexible.

In various work, extensions of the Spatial Model have been reported. For example, Benford et al. (1997) have introduced a concept of 'third party objects', which 'intervene' between objects and transform the nature and level of the awareness that the objects might otherwise have, and, importantly, Rodden (1996) has reinterpreted the Spatial Model in terms of spaces, which can be represented as graphs of interconnected objects.

5.2. The Aether Model

Our further development of the Spatial Model and the idea of an 'awareness engine' resulted from our previous studies like @work (Tollmar et al. 1996) and related projects such as CoDesk (Tollmar and

Sundblad 1995) where different awareness clues for supporting information sharing and casual interaction are provided. CoDesk was developed as an open environment where new applications could be added for specific tasks like editing or communication. Other systems have been taking similar approaches, e.g. GroupDesk (Fuchs et al. 1995) or TeamRooms (Roseman and Greenberg 1996). We have been using CoDesk as a 'target system' for our awareness engine, so as an introduction to the Aether model we will present how the awareness engine would relate to the overall architecture of a system like CoDesk.

The Structure of the System

We place the awareness engine at a basic level of system architecture (Figure 5.1). The engine is intended to provide applications with the necessary information about what users are doing or have done.

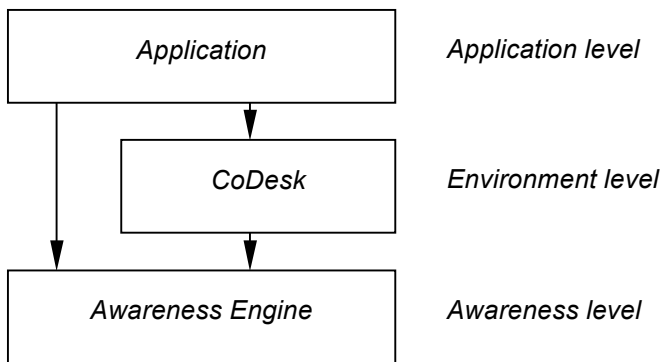


Figure 5.1 The Awareness Engine in the structure of the CoDesk system.

The second level is that of the environment. This will include all the basic functionality: shared file access, access control, versioning, communication channels, etc. All these functions are to be built on top of the awareness engine.

The top level is the application level where specific awareness information is collated and presented to the user. Applications are written based on the functionality provided by the second level. They can interact with the awareness engine in two ways: by interacting with the environment or by directly accessing the engine.

The Semantic Network

Traditional CSCW systems usually keep a structural network of objects. For example, a classical shared file system can be represented as a tree structure by means of the ‘containment’ relation. Other kinds of relation can have their own representation. For example, ownership may be represented in terms of parameters associated with relevant files or folders. Inspired by systems like GroupDesk, we also integrate representations of users and groups, as well as the result of their actions, into the structure obtaining a semantic network that forms a “representation of the working context” (Fuchs et al. 1995). This network, made of objects interconnected by directed relations, comprises the space in which awareness computations are done.

The objects in the network can be any entity (files, folders, applications, people, groups, sessions, whatever) defined by the environment and its applications. The awareness engine will treat all objects in the same way making no assumptions about the kinds of thing the objects represent. The relations that connect the different objects can also be of any type: structural relations (e.g. containment), user interaction relations (e.g. open file), property relations, and so forth. Once again it is up to the environment and its applications to define the specific type of relations. This semantic network creates a space in the sense similar to that suggested by Rodden (1996). This network will be the space in which aura, nimbus and focus are defined and in which the awareness levels between the different objects are computed.

Moving Away from Events

In many existing CSCW systems awareness information is obtained by means of events. User actions like file access, modifications, etc., are monitored, selected according to some criteria, and eventually recorded as event lists. Accordingly, phrases like ‘event manager’ or ‘event distribution’ are common in many system descriptions. For example, Fuchs et al.’s GroupDesk keeps lists of events, which are used to provide ‘asynchronous awareness’, even if some of the information in this event list duplicates information, which could be derived from the semantic network. Events are discharged based on some distribution strategies defined in advance. As Fuchs et al. show, such event-based systems seem to work satisfactorily for situations where workflow can be clearly defined in advance or if the application is known from the beginning.

However, as we remarked in the Introduction, much of the promise of awareness-oriented CSCW systems lies in their potential to offer a flexible alternative to strictly defined workflow approaches. So it would be somewhat ironic if an awareness mechanism only worked adequately in tandem with a system supporting somewhat rigid workflow. In contrast, systems like @work are intended to address groups of users with highly flexible working arrangements. This would make it hard to define appropriate selection criteria and distribution strategies in advance, an argument that is especially telling for systems, like CoDesk, which provide an environment for new applications (and hence new user-actions and event-types) to be readily built. Thus, for the systems we are interested in, an event distribution approach for supporting awareness does not seem appropriate.

As an alternative, we propose keeping all objects and relations in the net, even after their expiration, and using Spatial Model concepts to determine awareness levels for them. Instead of removing expired objects and relations we mark them as invalid. With this we have no need for event lists because the information those contain is now in the objects and relations of the network. What we obtain is a semantic network containing both the actual state of the system as well as all history information. Of course, the disadvantage of this approach is the quick growth of the size of the net but later we discuss some ways for reducing this size.

Reformulating 'Time' and 'Medium' Spatially

By keeping the invalid relations in the network, we can compute meaningful awareness information not only about what happens right now but also about past events. In this way we can say that our space equally contains two aspects: the semantic and the temporal. Time becomes now one of the 'dimensions' of the space, the concepts of the Spatial Model equally applying to it as to any other dimension.

A cognate approach can be taken to the notion of a 'medium' of communication. In the original Spatial Model, medium was loosely defined based on an intuitive understanding of this concept or, in Rodden's (1996) generalization, as a label on aura, nimbus and focus. In our case, as the space we have is not geometrical, we found it necessary to devote more attention to this concept. By medium we understand (a) a well-defined type of information, (b) a subspace that has the capability

to carry that specific information and (c) some objects that ‘understand’ that medium. Two objects that understand the same medium can communicate through it. Information will be generated by one of the objects, will travel through the medium subspace and will be received by the second object. An analogy is the radio, where an antenna transmits an electromagnetic wave that will propagate through all objects, even if these are not sensitive to it, while a radio, which can ‘understand’ the wave, will convert it to sound. For us, the medium’s subspace is made of objects and relations, even if those do not understand that respective medium. Aura, nimbus and focus will be defined per medium subspace.

Medium also has a time component. For example, a medium can define a subspace that contains only those objects and relations that have been valid during some time period. In this way we can obtain a time window. In this approach, a moment can be defined by collapsing the time window. Thus, in a ‘synchronous medium’ the time moment of ‘now’ is achieved by filtering out everything that is in the past. The ‘synchronous’ becomes a sub-case of the ‘asynchronous’. We suggest that this will facilitate systems to provide smooth transitions between different forms of communication, a point we shall return to at the end of this chapter.

Aura, Nimbus and Focus

Aura, in our model, is much the same as defined in the initial Spatial Model. It describes the potential for collaboration between two objects. If there is sufficient aura intersection (e.g. collision) then there is potential interaction between them. Given our approach to the notion of a ‘medium’, aura is defined by the medium rather than objects themselves. Nimbus and focus in our system have much the same meaning as in the Spatial Model. Each object or relation can control its focus and nimbus to specify their ‘willingness’ to become aware of others or fall within their awareness. Given the temporal aspects of medium just argued for, it should be observed that aura, nimbus and focus also have a time component. Thus, a user can ‘focus’ on the present moment, on the past or even on the future. This is exploited in a prototype versioning system presented later on.

We considered that our engine would be most flexible if both objects and relations in our network could have aura, nimbus and focus. By allowing a relation to have nimbus, we allow users to get notified about the presence of a relation. In this way, the user is aware not only of

objects, but also of the activity of others to the extent that this is depicted in the relations and changes to them. As we shall shortly see, however, this necessitates a reconceptualization of how awareness can propagate through our space.

Presence

People and other agents can manifest a presence in the network space. Presence is defined as: (a) the *agent*, (b) an *application that the person uses for manifesting its presence in one or more media* and (c) the *object where the presence is located in the net*. For our purposes, an agent can be a person, a group of people, or a computer agent. We say that an application is present in a medium if it ‘understands’ that respective medium. The object defining the location is much like Rodden's (1996) definition of presence in non-geometrical spaces. Like him, we allow an agent to be present in more than one place, in more than one medium, at any given moment.

Medium Consumption

In the initial Spatial Model the level of awareness that an object A has of an object B in medium M is computed, if aura collision exists, as “some function of A's focus on B in M and B's nimbus on A in M” (Benford et al. 1994). That is, the awareness-level is obtained through a negotiation between A and B, by means of controlling their respective foci and nimbi. We would like to add to this a new concept: space as an aura, nimbus and focus ‘consumer’. Our point is twofold: firstly, that the level of awareness should not depend only on the two objects, but also on the nature of the space between them, and secondly, that space cannot be seen as an empty, passive ‘container’ for aura, nimbus and focus if its fundamental structure is given by relations which can also have aura and the rest associated with them as in our inclusive notion of a semantic net rich in objects, relations and history information.

Fog provides a relevant analogy. Fog consumes part of the light and the sound passing through it, filtering out fine levels of details of the objects perceived through a fog-filled subspace. Indeed, fog not only fills a subspace but also comprises a crowd of very small objects, each of them with a specific behaviour and a filtering effect. It is this conception of space as always ‘filled’ which motivates our choice of name: Aether.

Accordingly, we redefine the level of awareness that object A has of object B in medium M, in case of aura collision, as being some function of A's focus on B in M ‘filtered by’ the space between A and B and B's

nimbus on A in M 'filtered by' the space between B and A. This definition necessitates two remarks concerning our notion of spaces consuming focus and the rest. First, consumption is not necessarily symmetrical, that is the consumption depends on the direction of the information flow. For example, the consumption of nimbus from A to B can be different to the one from B to A. Second, consumption need not have only a diminishing effect as some elements in a space may also amplify aura, nimbus or focus.

The idea of consumption relates with other concepts of the Spatial Model used for manipulating aura, nimbus and focus. For example adapters (Benford et al. 1994) and third party objects (Benford et al. 1997) are mechanisms used for the same purpose. The main difference is that both concepts use objects for this manipulation. Our model is more general, space itself having this effect on aura, nimbus and focus, with space comprising not just objects but also their relations in a structured semantic network. Objects and relations in our system thus have a double role. First they are the ones manifesting their presence by generating aura, nimbus and focus. At the same time they form the space of the model so they will become consumers of aura, nimbus and focus. As such, any object or relation in our system can be seen, and used, as an adapter or third party object.

The consumption of aura, nimbus and focus also has a meaning in the time dimension. After all, time does have an effect on the importance of objects and relations. For example, the importance of a certain user action might decrease in time; it might be important right now or five minutes later, but it might have no importance at all in one month.

According to this new definition, the computation of the aura, nimbus and focus becomes a negotiation between the two objects or relations (A and B), the medium that both of them 'understand' (M) and the space between the two. The medium M defines the auras of A and B, while the consumption of it is defined by the objects and relations on the relevant path(s) between them. If the auras intersect at some point at a high enough level, then focus and nimbus computations will take place. A will define its initial nimbus value and then the different objects and relations on the path(s) between A and B will consume it. B will define the initial value of its focus and again the objects and relations on the path(s) between the place B is focusing on and A will consume it. And so forth.

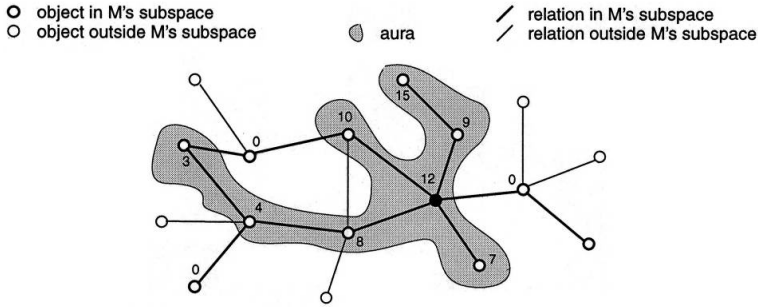


Figure 5.2 The Percolation of the Aura (or of the Nimbus).

The Percolation Mechanism

Before describing the implementation, let us explain how we see aura, nimbus and focus 'permeating the Aether'. Although there are a number of possibilities, we have explored a concept of percolation. Consider a case when the aura associated with an object A percolates from A (its 'source') through the objects and relations that belong to the relevant medium's subspace. The objects and relations which are neighbours of A will each consume the aura to some degree, as will, in turn, the neighbours of these neighbours and so forth. The process of percolation stops wherever the aura level decreases to some threshold or below (zero in our case).

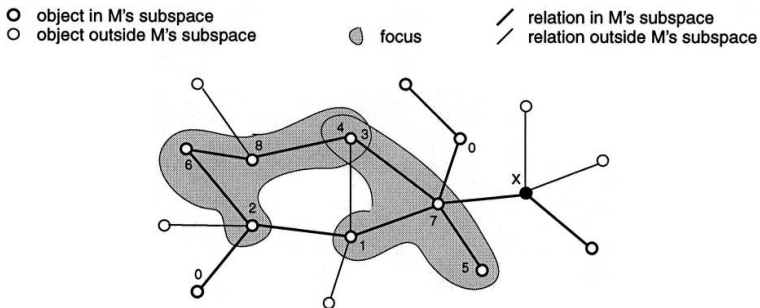


Figure 5.3 The Percolation of Focus.

We have an example of aura percolation in Figure 5.2. The numbers next to the different objects show the level of aura reaching it. We can see

how the aura of the object labelled 12 is consumed from one object to another, except between objects labelled 9 and 15, where it is amplified. The relations or objects that do not belong to the medium M subspace are not taken into consideration in the percolation.

In Figure 5.3 the focus of object X is made of two percolations, one centred in object 8 and one in object 7. The use of the percolation for focus is like saying “I am interested in these and what is around them.”

Implementation

Currently a running implementation of the Aether awareness engine is being experimented with. The engine maintains a network of objects and relations, though for reasons of parsimony and convenience, in our implementation the relations are defined as objects as well. Each relation points to two objects, a ‘from’ and a ‘to’ object, to define the directionality of the relations. An object can point to none, one or more relations. In this way, what we have called ‘objects’ and ‘relations’ so far can be thought of as specializations of a component concept.

A component (object or relation) has a nimbus value and a nimbus ‘strategy’ attached. The nimbus strategy defines the way nimbus percolation will take place. Each component can also have one or more focus points, each of them with a focus value and a focus strategy. It is up to the environment or any application to set the focus point(s), the nimbus/focus values and to set or modify the nimbus/focus strategies. A percolation strategy, be it for nimbus, focus or aura, is defined as a function that answers the question “is object X part of object Y’s nimbus/focus/aura?”

A medium in our implementation has to define (a) the medium’s subspace and (b) the aura percolation strategy. The subspace is defined by means of a function that answers the question “is object X in medium M’s subspace?” The presence of an agent is implemented by using a presence object. This object is connected to (a) a user, group or software agent by a ‘represents’ relation, (b) an application by a ‘uses’ relation and (c) a component in the net that defines the location by a ‘visits’ relation. Each component also contains the definition of the way in which aura, nimbus and focus are to be consumed. In the case of relations, consumption can vary according to the direction of percolation. Consumptions are defined as strategies that answer the question “how much of the aura/nimbus/focus value will remain?”

As we see, for each object the environment or the applications have to define a number of percolation and consumption strategies. In order to simplify things we have developed a number of basic strategies. These strategies can be logically combined in order to obtain more sophisticated ones. At the same time, any application can define new strategies rather than combine the pre-defined ones. In this way, it is hoped that the engine is both simple to use and flexible. An example of a pre-defined strategy is the 'now' medium subspace. The answer to "is object X in medium M's subspace?" will be "yes, if it is valid". Other strategies could allow percolation only through certain kinds of relations and objects. And so forth.

The Algorithm

Now we can define the awareness level computation algorithm. The computation is done for each medium separately. For a given object or relation (source), the engine starts from its neighbours as the first set of candidates, with a given initial strength. Each candidate is then checked as to whether it is included in the medium's subspace, by asking the medium's subspace strategy. If it is, then the aura (defined in the medium), nimbus or focus (defined in the origin object) strategy is asked to confirm that candidate. If it gets accepted then the candidate's consumption strategy is asked to compute the new strength that reached it. If there is some strength left, the candidate becomes part of the computed subspace, having its membership characterized by this strength. Its neighbours will be considered as candidates in the next step. This process continues until no other candidate can be considered.

The awareness level between two objects A and B is defined as four strength values: A's focus on B, A's nimbus to B, B's focus on A, B's nimbus to A. If A's and B's auras don't have common components (i.e. there is no adequate aura intersection), these values are null. After all the computations have been done, each presence object will get a vector of all components with whom it has aura collision and the respective awareness levels. As the intention is to provide as much generality as possible, the decision on how to interpret the four values is left to the application in question. One way would be to interpret them according to the 'modes of mutual awareness' as defined in the Benford et al. (1994) and Bowers (1993).

The computation is repeated after any change in the network, that is after any user action that effects the state of the system. In order to

reduce the data traffic between the engine and the applications, Aether keeps track of the awareness level between every presence object and the other components. After each re-computation, the new awareness levels are compared to the old ones and changes are reported to the applications.

We have defined an Application Programming Interface (API) for the Aether engine to support communication between it and CoDesk or the applications. The engine API is a very simple one, letting applications add, validate or invalidate relations and change strategies, and in the other direction, allowing the engine to announce awareness levels to the applications.

Computational Considerations

It is obvious that the Aether model will raise issues concerning computing time and network size, especially if relations and objects continue to be stored after their invalidation time. We can address the computational complexity problem in several ways. The engine currently makes use of a number of techniques to reduce the number of computations, for example, by performing multiple changes in the net before awareness level recomputation. Parallelization is another possible approach. As calculations in different media (and calculation of nimbus and focus in the same medium) can proceed independently of each other, CPUs can be allocated on a 'per medium' (or 'per awareness-subspace') basis.

Computation time can also be facilitated by carefully managing the size of the network. In this regard, we suggest that from time to time certain objects and relations can be removed in a process much like garbage collection. The question is which objects and relations are important to maintain and which are of lesser significance and can be removed. Ultimately, 'importance' can only be properly defined at the application level, though we do provide a general technique at the awareness engine level, which can be used quite flexibly in default of specific requirements made by the application.

In our model, the importance of a component is defined by its nimbus in time and our garbage collection algorithm periodically applies some consumption of this nimbus, in terms of a function which reduces its value according to the distance in time since invalidation. The engine then removes the components whose nimbus falls below a given

threshold. The system also removes relations connected to objects that have just been deleted and, if this now leaves objects without relations, then these are deleted too.

While this algorithm seems to work well for the applications we have experimented with, there is clearly scope for refining it. For example, we could relate the importance of an object to the number of times it has been ‘visited’ by users. An object visited often may be more important than one not visited at all. A visit could have the effect of incrementing the nimbus of the object, thus tending to increase its longevity.

5.3. The Aether Metrics

After the original publication of the Aether model, it became obvious that a mathematical interpretation of it is possible, an interpretation that opens up a number of new possibilities in terms of use of the Aether concept and in terms of practical implementations. The most important of it is that it allows for a natural integration of semantic networks with Shared Virtual Environments (SVR), allowing the combination of spatial based awareness, as described in the Spatial Model, with semantic based awareness, as defined by Aether.

Earlier work on the Spatial Model tried to tackle the problem of semantic awareness, that is, the awareness of objects that are not co-located but that are nevertheless in some sort of semantic relation to each other. In such a case one would want to be aware of such objects even if those would be distant in space. The definition of the level of awareness in the Spatial Model, where geometrical relations are used (distance), did not allow for some simple extension that would include these semantic relations.

With Aether we have shown how semantic networks could be used for providing awareness information in an information network. It would be of course very useful if we found a way in which the Spatial Model and Aether could be combined as that would allow for VR environments where awareness is not only geometrically related (co-presence) but would also superimpose semantic relations in such spaces.

One interesting approach to this problem is to consider the Aether *consumption* as being a *mathematical space*, defined by the objects of the semantic network and the relations between them. In such a case we could define *consumption* between two objects, A and B, as a kind of

‘semantic distance’ between them. Putting this in mathematical notations, we could define the following:

- A, B – two objects in our semantic space; as the network becomes a space we can call the objects ‘points’;
- M, M_1, M_2 – different media; the Aether model allows for different media in the semantic network;
- $f, f_1, f_2 \in \{\text{aura, nimbus, focus}\}$ - f, f_1, f_2 refer to aura, nimbus or focus subspaces;
- $ds(A, B, f, M)$ – is the semantic distance between A and B for sub-space f in medium M ;
- $d(A, B, f, M)$ - is the Euclidean distance between A and B for sub-space f in medium M ;
- $P(A, B)$ - the set of objects (points) belonging to the path between A and B , where the path is uniquely defined.

These definitions make up the new metric, one that we will call the AETHER METRIC. The Aether Metric, according to the way in which we defined consumption, has a number of interesting properties.

MEDIA DEPENDENCY. First, in the Aether model we considered that the consumption could be different in different media. Putting this in mathematical terms, that means that the distance from A to B in medium M_1 could be different than the distance from A to B in medium M_2 . In other words, we can say that the Aether metric is dependent on the media.

SUBSPACE DEPENDENCY. Another interesting property of consumption is that it can influence aura, nimbus and focus between the same two points in different ways. That means that the distance between A and B , in the case of aura, could be different from the distance from A to B , in the case of nimbus. In other words, the Aether metric is dependent on the subspace that we compute: aura, nimbus or focus.

ASYMMETRIC. The next interesting property of consumption is the fact that the consumption is not symmetric, that means, the consumption can be different if computed in one direction or in the other. Put otherwise, the distance from A to B could be different than the distance from B to A in the same medium and for the same subspace (aura, nimbus or focus). In other words the Aether metric is asymmetric.

NON-NON-NEGATIVITY. As already discussed in the previous sections, the Aether consumption doesn’t have to have a diminishing effect on aura,

nimbus or focus, but could also have an amplifying effect. In other words the distance from A to B can have any value, positive, zero or negative.

SPACE DEPENDENCY. The last property that we would like to mention here is one of great importance. As the space is made of the objects and the relations among them and as the consumption is a property of each of these objects and relations, the distance from A to B will depend on all objects that are on the path from A to B. This means that the objects influence the distance between two other objects.

These properties can be described with the mathematical notations that we defined previously:

- $ds(A, B, f, M1)$ can be different from $ds(A, B, f, M2)$;
- $ds(A, B, f1, M)$ can be different from $ds(A, B, f2, M)$;
- $ds(A, B, f, M)$ can be different from $ds(B, A, f, M)$;
- $ds(A, B, f, M)$ can be negative, zero or positive;
- $ds(A, B, f, M) = g(P(A, B))$ – the distance from A to B is influenced by the objects on the path from A to B;

In the case of 3D VR spaces, where the Spatial Model can define awareness relations, we normally have an Euclidian geometrical metric. As long as we apply this assumption, we would have the following properties for the definition of Space Model distance:

- $d(A, B, f, M) = d(B, A, f, M)$ – the distance between A and B is the same as the distance from B to A (symmetrical);
- $d(A, B, f, M1) = d(A, B, f, M2)$ – the distance between A and B is the same, regardless of the medium in which we compute it;
- $d(A, B, f1, M) = d(A, B, f2, M)$ – the distance between A and B is the same, regardless of the subspace (aura, nimbus or focus) for which we compute it;
- $d(A, B, f, M) \geq 0$ – the distance between A and B is a positive number and cannot be negative.

Based on these mathematical relations, we could conclude:

$$d(A, B, f, M) = d(A, B) = d(B, A) \geq 0$$

This means the geometrical metric is a subspace of the Aether metric and as such the Spatial Model becomes a sub-case of the Aether model.

Extending the Spatial Model with Aether

This important conclusion opens up a number of interesting possibilities of using the two models together. Mixing the geometrical based properties of the Spatial Model with the semantic based properties of the Aether model offers an interesting mix that could be used in solving a number of problems previously reported in the design of shared VR environments as well as in other shared applications.

Mixing the two models would allow designers to add semantic spaces to VR environments in a unifying system, which is governed in terms of awareness by an Aether engine that handles both the geometrical and the semantic aspects. Each space will have its own $d()$ function that defines the distance. In the case of the geometrical space the function can be the normal Euclidian geometrical definition of distance, though others are of course possible as well. In the case of the semantic network, the function will contain an algorithm very similar to the one in our engine. The focus and nimbus would continue to be the control mechanisms in the space but they would encompass not only the geometrical relations between avatar and the different VR artefacts, but would also include the semantic relations between them. The application areas of such a mixture are multiple as we will see further on.

5.4. Conclusions

This chapter has introduced an extension to the Spatial Model, called Aether, which can be applied to interactive systems based on semantic networks. As we have shown, the model proposes a generic way to support awareness in general at system level. It does that by taking the 'negotiated awareness level' from the VR-based Spatial Model and introduces it in applications that have semantic networked information at the basis.

By this it offers a softer approach to the issues regarding data collection, filtering and interpretation, issues that, as seen in our projects, are sometimes difficult to solve with predefined solutions. Aether allows these solutions to emerge out of a negotiated interplay of ones interest and the other ones' activities. In implementing the model, the designer can decide to leave the control of nimbus, focus and aura under the control of the user. In this way Aether can be used to implement translucent technologies where the user is in charge of the tools that influence the negotiated awareness.

Aether also provides a novel approach for semantic networks, which normally handle social awareness with event-based mechanisms. This is important because event-based mechanisms need normally clear-cut decisions regarding relevance to be taken at the moment in which an event appears. Aether allows this decision to be taken later on, awareness information being kept in the semantic network. Relevance is re-evaluated constantly, via the percolation algorithm, what is of importance for users being under constant consideration. In this way implementations based on Aether have a better chance to provide the user with the needed information at the best possible moment.

Another novelty in Aether is the suggestion for both *objects* and *relations* to have aura, nimbus and focus. Comparing this to the Spatial Model, it is as saying that both objects within a space as well as the space itself would have these properties.

By showing that the Spatial Model is a subspace of the Aether Metrics, we open the possibility to combine 3D shared VR environments with shared semantic networks. This opens up a number of possibilities, both in relation to awareness as well as in relation to other design problems in such systems. We will consider some of these in the following chapter, intending both to bring confirmation to our model and to suggest to other researchers and designers new ways for approaching similar issues.

We want to finish by drawing out a general conclusion for CSCW research from the Aether model. We remarked above that we treat time as another dimension in constructing the graph 'spaces' over which awareness computations are done, enabling various 'awareness windows' on past events to exist. Equally, by manipulating the form that focus takes, a user can broaden or restrict the extent of objects and relations of potential relevance to their work. This approach enables us to capture within a unified framework all of the forms of awareness in cooperative systems identified by Fuchs et al. (1995): coupled-synchronous (what is currently happening in the actual scope of work); uncoupled-synchronous (what happens currently anywhere else of importance); coupled-asynchronous (what happened in the actual scope of work since the last access); uncoupled-asynchronous (what happened anywhere else of importance since the last access).

'Actual scope' means, in our model, 'being in the focus of the user', 'of importance' means 'the user is in the nimbus of an object or a relation', 'currently' means 'the time focus is now', and 'since the last access'

means ‘in the time focus between the user’s last access and now’. By manipulating the aura, focus and nimbus of the user and of the objects of the system, the awareness engine can generate awareness information for all these situations. But more than this, by translating the coupled-uncoupled and synchronous-asynchronous distinctions into concepts that admit continuous variations, we can identify all the ‘points in between’.

By offering a framework in which synchronous and asynchronous awareness can be supported equally, we ‘deconstruct’ this distinction in a unified approach. This is a powerful conclusion because the distinction between synchronous and asynchronous is used so very commonly - often as a way of distinguishing between different kinds of systems. While synchronous-asynchronous may often be a clear distinction at system levels where different communication protocols are discussed, perhaps we should not crudely transpose the distinction so that it classifies different types of awareness, still less different types of cooperative work. What matters to cooperative work as it is experienced, we suggest, is the integration of different streams of work, which may be on many different time scales and show varying degrees of relevance to the matter at hand. Having a level of system architecture where different forms of awareness can all be supported together seems most appropriate to this image. The Aether model and our experimental awareness engine comprise our attempt at this.

In order to validate the model, we present in the following chapter some small applications that we have developed as well some ideas about how other systems can be implemented.

6. Applications of Aether

Aether, the theoretical concept for supporting awareness, presented in the previous chapter, has over time generated further developments, by the authors of the paper introducing the model (Sandor et al. 1997) as well as by other researchers and developers. We find it beneficial for this present thesis to look at these later developments, especially as one rarely has the occasion to look back at such work and to consider how others have continued the concepts. These developments will contribute in our final discussion on awareness support and will also provide ample ground for ideas of future investigation, by us or by other researchers.

The first section will present a number of applications of the Aether model in shared semantic networks. We will show how the model can be applied for supporting functions like versioning, history, access control or flexible workflow systems.

The second section, based on the mathematical interpretation presented in section 5.5, will look at how the Aether model can be used in Shared VR Environments (SVE). We will suggest an approach to semantic scoping of VR scenes and we will discuss at length a novel way to handle self-emerging, dynamic groups in SVEs. This will lead us to the introduction of the concept of heat-maps in relation to awareness.

The third section will show an experimental project, called Heatmap, in which we have tested the idea of using group-based awareness as an alternative to individual-based awareness. This subsection explains our proposed idea, the prototype and the implementation as well as reaction and conclusions on the experimented design. We will then show how this concept, tested here in a museum environment, could be used in work-related settings as well.

Before ending this chapter with a section where we conclude our ideas and findings, we will present in a separate section the way in which other researchers have used Aether, either as a theoretical foundation for their

own work or as a model for implementing awareness related functions in CSCW systems.

By considering all these various possibilities and applications of the Aether model, this chapter will contribute by highlighting the potential of the model we introduced while in the same time discussing issues regarding social awareness that will be of relevance for the final discussion in the Conclusions chapter.

6.1. Aether and Shared Semantic Networks

In order to demonstrate the feasibility of our Aether model, we have developed a number of small applications. We have primarily concentrated on showing how services often thought to be fundamental to cooperative applications can be readily supported in the Aether model, in particular the management of versioning, history and access control. To demonstrate the generality of our model, we have also simulated a version of Isaacs et al. (1996) Piazza prototype awareness system. We briefly discuss these applications in turn.

Versioning and History

Some kind of versioning is normally needed in CSCW applications. We will show one way of implementing it with the awareness engine. Each version of a document is represented as an object in our net. A 'is-previous-version-of' relation binds the different versions into a version tree. A user can access the latest version or can focus on some previous time moment, by selecting the appropriate focus strategy, and access the versions that existed at that moment. Users could also have access to any other information about these documents, like for example, who changed them and who has read them, by controlling nimbus and focus.

In many cases, it is likely that, after a while the number of versions would be too big and some would have to be removed. The point would be to remove the minor versions and to keep the important ones. For this, the versioning module would have to set the nimbus of the different versions in such a way that, by applying the garbage collection algorithm, the desired effect would be obtained. One way to do this would be to relate the level of nimbus in time with how much the new version differs from the previous one. In case of minor changes the nimbus would be small, while extensive changes would generate a high nimbus and would remain in the system for a long time.

History is a related problem, but it refers to user actions over time instead of documents. Very many history events can be deduced from the time information of the different relations that represent user actions. By setting the focus strategy to some moment in time, the user would be notified about the state of the system at that time around the point of focus. By displaying all the changes in the objects and relations (creation or invalidation) between two moments in time, we could reconstruct a history of events. It may be that some components have been removed from the network but, as important events tend to be more long-lasting, this method of reconstructing history should be satisfactory for many purposes.

Access Control

Another important functionality needed in CSCW is access control. An interesting way to do this in the Aether model is to have access control media. For example, we could define a 'Top Secret' medium. The boundaries protecting an area that contains sensitive information could consume completely the aura, nimbus and focus of all other access media, except for the 'Top Secret' one. Only users that are allowed to use this medium would be able to notice the presence of those objects and access them. In this approach, boundaries can be realized by particular kinds of objects in the net, which consume aura and the rest and can exert constraints on navigation through the net (Bowers, 1993).

Another interesting approach is the one suggested in Benford et al. (1996). A 'Foyer' could be used for entering the system. One of the functions of the foyer is to "enhance security by providing a single point of entry... within which incoming and outgoing people are made publicly visible and hence accountable". The system could have such an entry point where all users would have to start and at which their capabilities (or 'strategies' in the sense used above) for manipulating and consuming aura, focus and nimbus would be defined. A guest, to give just one possible example, may have a more limited focus (so that they tend to access less), but a larger nimbus (so that other users are likely to be made aware of them and their activities) than a 'registered user'. As these capabilities can be defined on a per medium basis, a very flexible approach to access control is possible through the Aether model. We refer to a given profile of awareness manipulation and consumption strategies as a 'character'. While taking on a specified character may be necessary to gain full access to a certain medium subspace, this is much

more flexible than traditional approaches which typically give and withhold ‘access rights’ to ‘roles’.

A Simulated Piazza

Our final test of the feasibility of the Aether model and our awareness engine implementation is a ‘simulation’ of Piazza, an application prototyped by Isaacs et al. (1996), which provides users with information concerning “others, who are doing similar tasks when they are using their computers, thereby enabling unintended interactions”. Piazza comprises a number of sub-applications, two of which we have re-implemented using the concepts of the Aether model: Gallery which allows the user to get information about other group members, and Encounter, a component which can be added to any application and which makes users aware of others who may be “nearby”.

Our Gallery is an application that sets its focus on the people selected by the user. The application uses a percolation strategy that will define the focus in terms of those relations around a person that show their current activities. When such activities exist, the application will present to the user what the others are doing and where in the network space they are. Our version of Encounter is a file browser that, in addition to traditional functionality, informs the user about the presence of others in the same subdirectory of the file system. The application sets the focus around the directory where the user is located and uses a strategy that monitors any other presence in that place. Our treatment of temporal relations, as also being part of the network, enables us to entertain extensions of Isaacs et al.’s work so that users can become selectively aware of others who have shared the same directory space at different past times. Accordingly, an Encounter application built upon our awareness engine may be able to support a richer set of “unintended interactions” and social encounters than Isaacs et al. discuss.

Flexible Workflow Systems

It is easy to see how the basic functionality we have discussed could be combined in, say, a revised and more flexible approach to workflow support. Rodden (1996) observes that most workflow systems depend at some level on a graph specifying transitions between states in the workflow. Such graphs can constitute a graph-space over which aura, focus and nimbus can be defined and manipulated. In this way, participants in a workflow can be made aware of activities ‘upstream’,

which are about to become their responsibility, as well as of activities ‘downstream’, which follow on from what they have completed. In Aether, we would add to the graph the documents in their various versions, representations of the users themselves, and any other object or relation of significance, and do so while the workflow is being enacted. In this way, the structure of a workflow can dynamically unfold and be enriched over time, with participants being present in and aware of various sub-graphs, as determined by the awareness computations. This approach has two attractive consequences. First, workflow graphs are no longer to be seen as stipulations of the possible states of the workflow. They become instead ‘seeds’ for a semantic net, which will be added to as the workflow unfolds. Indeed, in some implementations, the pre-defined workflow states might even get garbage collected if they are infrequently visited, that is, if they become irrelevant to the way the work has turned out. Secondly, as participants have points of presence within the graphs, which they themselves add to and manipulate their awareness within, the Aether model could encourage workflow systems which support ‘workflow from within’, the self-organizing and emergent structuring of work in response to contingencies, and not just mandate ‘workflow from without’, the execution of pre-defined procedures no matter what (Bowers et al. 1995).

6.2. Aether and VR environments

The Aether metrics opens, as previously demonstrated, to VR environments and especially to shared VR environments (SVE) a new layer of semantic information. We will look here at a couple of direct applications of this superimposition of geometrical and semantic information.

Using Aether for Semantic Scoping in 3D Environments

Increasing the speed of rendering in 3D SVE, as well as download time reduction in distributed virtual environments, have long been subjects of study. Various methods have been suggested, most of which are based on geometrical properties of space and objects.

This part will present a new approach that suggests the use of awareness information for rendering. In this way, semantic properties are used for defining the level of detail of the rendering of particular objects. The method suggests the use of parallel structures defining objects in a scene

in different levels of detail. These would lead to faster rendering and reduced download time. We will present how this approach can also be used for representing and rendering self-emerging groups in SVE, in terms defined previously.

One of the most important problems in developing VR environments is the rendering algorithm of the 3D scenes. These algorithms tend to be very complex and tend to use a lot of resources. The most important aspect of such an algorithm is the time in which a new frame can be computed. Ideally, a new frame should be displayed about 25 times per second, but 10-15 frames per second speed is acceptable. Unfortunately, this is hard to achieve, especially in VR environments where we have very complex scenes, sometimes reaching millions of polygons that need to be rendered, for an example see Wonka et al. (2000). Rendering such a complex scene takes too long to perform at each frame.

The problem is more complex in the case of SVE where we have more than one embodiment. That means that we have to perform the rendering for each individual participant, and again, for each frame. If we are talking about hundreds of participants at the same time, things are not so simple any longer. In such an environment, which normally is accessed over the Internet, one solution is to send to the user's machine the scene graph and let it do the rendering for the respective participant. In the case of a complex scene we have the problem of network download time. Waiting for minutes to download a 3D world is no fun. It should be noticed that such a SVE contains also a lot of dynamic elements, especially the embodiments of the other participants. Their change (movement, gesture, etc.) must be sent over the Internet to each of the participants so that their client can render the next frames properly.

Considering all this, it is obvious that the VR community spends a lot of time trying to find algorithms that reduce the amount of information transferred over the Internet and that increase the speed of the rendering.

Any VR scene is represented as a structured graph. To begin with, let us think only about the static structures in a very large scene. The rendering algorithm will parse this complete structure, one or more times, depending on the used algorithm. It is not important if the viewer (the person that will see the rendering) has the house in front of his embodiment or in some peripheral area of his view-angle, or if the house

is so far away that the different details, as the handle on a door, cannot be seen.

We suggest the awareness level between the viewer (its embodiment) and the scene objects to be used for a more efficient rendering of the scene. The new method is based on two separate computations. The first one will traverse the structure and will create for each complex node (let us say a node that has above 100 sub-nodes or leaves) an alternative simpler representation (let us say with up to 10 sub-nodes). This alternative representation becomes one of the sub-nodes of the respective node and will be specially marked within the tree structure. This computation will be performed at different levels of a very complicated scene so that all relevant nodes from different levels will have the simplified representation. In computing this representation, the algorithm will, of course, give up on some details or will even use some incorrect physical rules. What is important is to get a simple structure that is an approximate representation of a complex structure.

For example, the wall in one room will be represented as a rectangle with a texture on it. The texture is computed by properly parsing the structure that defines the objects next to the wall. At the following upper level, the house will be represented by a square with texture on it, the texture being properly computed based on the structure that defines the architecture of the house. A Christmas tree will be replaced by a cone, which has a texture that is properly computed from the detailed elements (the branches, the needles, and the decorations).

This first computation can be executed as soon as we have this static structure. As this could be done before someone tries to render the 3D scene, computational time is no longer an issue. Once this computation is executed, we will have a new tree representation that will include not only the original components but for different nodes also an alternative, simplified representation.

At the moment when a rendering is needed, the rendering algorithm will use the information about the awareness level between each of the objects and the viewer. Suppose that the algorithm has reached a certain node, which has two representations (the original, complex one and the new, simple one). If the awareness level between that node and the viewer is above a predefined threshold, then the rendering algorithm will parse further the complex structure. Otherwise, the parsing will continue with the simplified structure. The point is that the awareness level can be

considered an indication of how important to the view of the user that respective object is. If the object is close or in the centre of the focus (viewing angle), then the awareness level will be high so the detailed structure will be used in order to produce a correct image. If on the contrary, the objects are far away or not in the centre of attention of the user, then the simple structure will be used. By this, we reduce the time that the rendering needs to parse the structure, as only the important parts are parsed completely, while the others are parsed strictly in the initial computation.

In best cases, the method has the potential of reducing the rendering time with some order of magnitude. Actually, the method suggests to make part of the rendering in advance and to do in real-time only the rendering of relevant objects.

Another version that might bring more precision to the simple structure that we compute, is to run the first computation not only before using the system, but from time to time also during the use of the system (for example every minute or so). An interesting approach that should be tested would be to use concurrent processes. The first process would be the rendering one, the one that is to be executed from every frame. This process would have the highest priority. Then, for each important node, we would spawn a new process that should, from time to time, recompute the alternative structure for that node. The priority of those processes should be according to the awareness level between viewer and those points. In this way, the alternative structure will be recomputed as the awareness of that object increases until it reaches the threshold level when the complex structure is used.

This technique of replacing a complex object with a simpler one plus a texture has been used before, the most common example being trees. A tree is represented directly by its simple structure (the cone and some texture) instead of the complex one. But, what we suggest here is to keep both the complex and the simple structure at the disposal of the rendering algorithm to choose the one to parse further, based on the awareness relevance.

The method could be also successfully applied in order to speed up loading time of 3D worlds over the Internet. The client would load first the top level of the scene with the simplified structure of the objects at that level. The rendering could start directly, even if the quality of the image would not be perfect. In time, any object that comes in the focus

and proximity of the user would be loaded over the net with the complex structure so that a precise rendering can be done. If the user does not access certain spaces of a world, those spaces will never be loaded in their complex version, only in the simple one. This would reduce net traffic and start-up time. In the case of structure changes, again the method would simplify things, because only simple representations of the changes would need to be sent over as long as those happen in an area of lesser interest to the user.

Self-emerging Groups and the Aether Model

Handling groups in Shared Virtual Environments (SVE) has been a topic of previous research. Even if different solutions have been suggested, most of them address *explicit* groups. In this part we will present some ideas about how self-emerging groups could be handled in such environments, by using awareness concepts like nimbus and focus. We will present how to compute such groups and how to use these methods in applications.

Previous research has addressed the problems of *explicit* groups, that is, groups where members explicitly declare their belonging to the group and different solutions have been suggested. More difficult seems to be the problem of *self-emerging*, or *implicit*, groups. This problem has been discussed less often and any solution that was offered was rather artificial and did not fit properly in the Spatial Model concept.

Reinterpreting Groups

We will try to present here a way of talking about self-emerging groups using concepts from the Spatial and Aether models. We will start by defining groups as sets of objects (such as humans - in the VR context embodiments and software agents) with some common property. In our day-by-day life, we encounter groups of two types:

- Groups that contain objects that are geometrically located near each other;
- Groups that contain objects that have a common interest.

An example of the first type is a group of strikers near a workplace. An example of the second type is the group of people sitting at home in their sofas and watching the same football game on TV. Even if these people are not co-located, their common interest will provide them with a certain group identity, for example, they will start shouting at the same

moment when their team scores. We also encounter groups that are both co-located and driven by a common interest; for example the people on a stadium that are watching a football game.

Let us consider the first case, of a group of embodiments in a VR environment that are co-located. If we would graphically represent their nimbi we would see that these overlap. In the same manner we could represent graphically the focus of a group of embodiments that all focus on the same object in the space. The result will be that those foci would overlap on top of that object. We could use these nimbi and foci overlapping in order to define and to identify groups in SVE:

- Groups of objects that have overlapping nimbi;
- Groups of objects that have overlapping foci.

For convenience, we will call the first type *nimbus-based* groups and the second type *focus-based* groups. It is worth mentioning that this is a somewhat artificial distinction but we hope that it will serve us well.

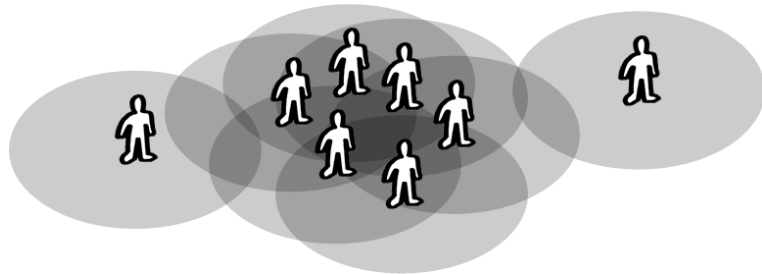


Figure 6.1 The Nimbus-based group.

NIMBUS-BASED GROUPS. In order to explain better what we mean by nimbus-based groups, let us think about nimbus and focus as heat. If we would draw a 3D map of the nimbi of all objects at a given moment in time we would obtain a sort of heat map. The map will contain hot spots obtained as an effect of overlapping nimbi (Figure 6.1). Each such hot spot denotes a nimbus-based group. The hotter the spot the more of a group it is. It means either the co-location of more objects or the fact that the objects are closer to each other, that is, we either have a bigger group or a more coherent one.

FOCUS-BASED GROUPS. The same procedure can be applied for focus, similarly obtaining focus-based hot spots (Figure 6.2). Note that the focus-based hot spots will denote the artefact that the group is focusing

at and not the group itself. The members of the group might be in some other places but their focus will ‘cover’ the hot spot artefact. The ‘hotter’ the artefact is, the more objects are focused on it, or more in the centre of focus is that artefact. In a certain sense the ‘temperature’ of the hot spot will define another kind of group coherence.

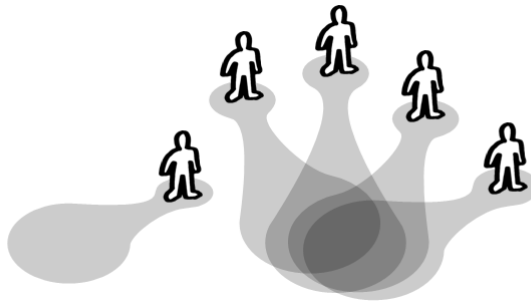


Figure 6.2 Focus-based group.

Other approaches to Groups

The notion of focus-based groups is somewhat related to the third-party objects (Benford et al. 1997). The fact that two or more objects focus on the same artefact might change the perception that those objects have of each other (their awareness level might increase). In such a case the artefact would be a third-party object and it is the artefact itself that carries the property of changing the awareness level (or its components, the nimbus and the focus).

In self-emerging groups based on the Aether model, no artefact is needed for focus-based groups to emerge. It is the space formed by the semantic network that can itself generate sufficient overlapping focus for groups to be identified. Additionally, the group concept introduced with Aether allows such groups to be identified in less intuitive settings, semantic networks. In the same time, by allowing the integration of VR environments with semantic information, the model for self-emerging groups in Aether will allow for groups to be formed based on both geometrical and semantic overlapping, be it of focus or nimbus.

The VR worlds are synchronous by nature. In the case of the Aether model we do not have this restriction. We can define focus-based groups that would contain objects that focus on some artefact, but not

necessarily at the same time. As time consumes focus, it would happen that, if the user does not focus again on the same artefact, he would be excluded from the group. The same thing could happen to the nimbus-based groups. If an embodiment does not visit some place again it might lose the respective group 'membership'.

Computing the Heat Maps

From what we have been describing till now it is obvious that we have to compute a heat map for the nimbi and one for the foci. For now let us suppose that we have a formal definition of this computation.

Theoretically, this map has to be computed for each frame (if we talk about VR) and for each point of the space. This computation might not be cheap in terms of resources. On the other hand we could do the computation only from time to time and not for each frame. Or we could define a set of potential hot spots and only values for those points would be measured. In the case of focus-based groups, it would be easy to consider certain artefacts from the space as potential hot spots (like all the embodiments plus all objects that users might focus on). In the case of the nimbus-based groups, it might be more difficult to define such potential hot spots.

Rendering Dynamic Groups in SVEs

Once self-emerging groups are identified in an SVE, we could consider the use of semantic scoping (described in the previous sub-section) for rendering the representation of that group. In this case we are talking about a dynamic structure within the graph of the VR environment.

Once our heat algorithm has noticed a nimbus-based hot spot the pre-rendering algorithm could automatically start on the embodiments (or objects) that are part of the group. In the same way as for static structures, the algorithm would compute an alternative simplified view of the group. Again, the frame-rendering algorithm would decide if to use the complete group description or the simplified one, according to the awareness level between the viewer and the hot spot. In such a case, a viewer placed far away would get the simplified view, while a viewer that is part of the group would get the detailed view of the group members.

This approach allows for sub-grouping as well, where a big group is represented as a group of groups. At each level, a simplified representation could be computed automatically, so that one user could

see only the complete group, the sub-groups or the individual members of the sub-groups.

We see that the basic difference between rendering the static and the dynamic structures is the fact that the pre-rendering takes place only at the beginning, for the static structures, or repeatedly, for the dynamic ones.

Applications of the Concept - Heaven and Hell Live

In the evaluation of “Heaven and Hell Live” (Benford et al. 1998), a TV-broadcast of a Shared Virtual Environment, produced by Illuminations Ltd. London, it was noted that the virtual cameramen had difficulty finding areas of interest. It has been suggested that asymmetric auras might have solved the problem, giving the cameraman a larger focus than the other participants and thus a more detailed view of the environment.

We suggest that instead it would be interesting to try a (semi)-autonomous camera, which automatically seeks out what seems to interest the largest number of participants at the time. This means the cameras could focus on the hottest hot spots at any given moment in time. These could be either nimbus-based hot spots (groups) or focus-based spots (places or artefacts of common interest). If the system had more than one camera, these could focus on the top hot spots according to their ‘temperature’. Or the system could try to find the fastest warming up places so that the cameras might have time to smoothly move to those places. All this could happen under the control of a person (director), who might be able to reassign cameras to hot spots and choose the camera to be broadcasted. This person would be permanently presented with the current list of hot spots, nimbus-based as well as focus-based.

6.3. HeatMap

Based on the idea of computing heat-maps of activity in a semantic network, this part of the thesis will present an explorative project where we used a sensor network for group awareness support.

We will discuss the previous approaches in using sensors for awareness and availability information and will present our own *translucent* approach. Translucence was suggested to us by 'techno-methodology' (Dourish and Button 1998), an ethno-methodologically inspired

approach to software design based on “the system giving an account of itself”.

We will explain what we understand by *group awareness* and how we envisioned and implemented a system called Heatmap to support group awareness. A prototype developed for the Technical Museum in Stockholm is presented as well as the results of a small study on the public use of our system. This experiment allows us to draw a number of conclusions on the use of sensors, on group awareness, on the ‘translucent’ type of solutions that we advocate and on affordance recycling.

In developing the idea of group awareness we will use one of the ideas formulated above, that of using a 'heat map'-inspired approach to identifying 'hot' areas of interest in a given space, be it 3D or semantic. This can provide users, in an intuitive way, with awareness of what is going on in spaces that are outside the reach of their physical senses, by this offering a better background for social awareness and for more intense collaboration.

We were offered the possibility to experiment with this concept under the framework of the Daphne project (Sundblad 2005). Funded by the Swedish Foundation for Strategic Research, the project was a three-year cooperation between CID at KTH and The Swedish Institute of Computer Science (SICS). The goals of the project were defined as follows:

- To develop new theories and concepts for understanding how interaction can be supported across a wide range of physical settings each offering different levels of digital support.
- To generate new design and evaluation methods appropriate to these technologies based on a combination of approaches from cognitive science, social science and design.
- To create new devices to establish new relationships between users, activities and devices across a broad set of physical environments.
- To develop new forms of adaptive infrastructure to support heterogeneous environments offering different levels of support and enabling different classes of device as they move between varied locales.

The approach was to use a number of small application projects from which the user experience informs and develops knowledge on research challenges, within infrastructure, interaction, design and evaluation methods, which in turn call for technical development and research (on infrastructure and tools) for new applications. For these applications the researchers have been looking at different digitally rich and digitally sparse spaces, like homes, working places, public spaces and places “in-between” (transition spaces).

One of the technologies that the project looked into was sensor networks, consisting of cheap, energy efficient, very small sensors that could be deployed in big numbers, forming ad-hoc networks around a given area. While this technology is close to being deployed around us, little has been studied on how it could be used for applications in our daily life. Even less is understood on the impact that such a technology could have on people or how interaction and control would be maintained in the hands of the user.

Sensors and Awareness

Present day technology allows for very small sized, energy efficient sensors that can form networks. Such a network normally consists of a small number of simple sensors like accelerometers, temperature or pressure sensors, microphones, etc. as well as some sort of communication system. For example, Smartits (Holmquist et al. 2004) contain a flexible number of such sensors plus wireless communication capabilities in a small package that is simple to program and to be deployed. The usual concept is to use big numbers of such elements to spread them around a given area and to collect all that data and transform it in some meaningful information. Military applications have been developed, but such technology could be used in daily life settings as well.

One area where sensors have been pointed out as an alternative to other techniques is the area of awareness and availability. For example, Fogarty et al. (2005) use sensors for predicting interruptability and availability of people. Sensors are seen as a convenient way of automatically collecting data that, based on advanced prediction mechanisms, would permit identification of human activity patterns, in turn allowing for automatic predictions related to the needs of the user. While most of these projects focus on using sensors for identifying patterns in human activity, we

believe that such models need to be complemented with features that come into play especially when patterns are broken (or are simply evolving) for reasons that are independent of the model and the computer system.

While sensors allow for such systems, they also introduce a number of potential problems. For example the feeling of being monitored and the related concerns on privacy are not to be ignored. Therefore, it is important to properly consider the control mechanisms that the users have at their disposal in interacting with such systems.

Translucence and Glance Views

In order to solve the problem of how data should be consolidated and interpreted by the computer, based on previous research (Bogdan and Severinson 2004), we argue for a technically translucent model of presence and availability. Such models should present their presence forecast to the users in a way which will (a) let the user understand how the forecast was made and (b) give the users the necessary information to make their own inference about presence and availability of colleagues. Translucence was suggested to us by “techno-methodology” (Dourish and Button 1998), an ethno-methodologically inspired approach to software design based on “the system giving an account of itself”. While their recommendation is general, we were interested in how to apply it to presence-forecasting sensor-mediated systems.

One immediate application of the translucent approach is the display of availability and presence information using glances. Glance views have been encountered in control room settings (Heath and Luff 1991) and they allow users to monitor the setting “out of the corner of their eye”, while being engaged in other activities. Glances show information that lets the user quickly get an understanding of what is going on and trace back the information displayed to the original data sources (sensors, etc). In other words the details of the glance view can be ‘decoded’ by the user in a translucent manner once the user attention turns towards them.

This approach was also used in a small prototype system presented in Bogdan and Severinson (2004). There, an application was developed to support presence and availability awareness by means of sensorial information in a distributed group working on a document from their homes. The translucence-oriented approach was used to show the users what each type of sensor detects, and how it can be installed. In the same

line of thought, users were asked to install their sensors themselves in their homes. To accommodate that, the sensors had to be designed and constructed in a robust fashion, so less technically initiated users could ‘play’ with their installation without a high risk of damaging the sensors or the overall system. By adjusting the sensors in such personal manner, users could thus construct a sensorial installation that best helped the rest of the group.

Another way in which they attempted to increase system translucence was to provide users with the necessary interface means to document their habits in relation to the sensors, for other users to see how they should qualify the sensorial information. Users have used this function to ‘amend’ the understanding of what the sensors express in relation to their activities. An interesting example reported by the authors is one where the user defines one sensor to mean “do not disturb”, i.e. lack of availability instead of the expected opposite.

The results of their pilot study using this application were encouraging, as users appreciated their discretion over the sensors, and made use of it in ways specific to their particular environment, including their particular patterns of presence and availability and the corresponding ways in which such patterns can be discontinued at times.

Group activity

Most systems designed to encourage informal communication focus on collecting, predicting and presenting presence and availability information about the different individuals from a given group (Tollmar et al. 1996). The assumption is that some other person will look for this information and, when the proper moment appears (in terms of presence and availability), communication will be started. In our system, we will try to prove another concept regarding informal communication. We believe that in order for such communication to occur there is a clear need for the people involved to be aware of what the group is doing and what the group has been doing in the last period of time.

The comments of the users to systems like @work point out a need to sometimes have simple overviews of what happens in the workplace. This is an even more stringent need today, as patterns of work for individuals and organizations change quickly. As previously discussed, modern digital devices and communication technologies allow for flexible, mobile ways of working where people are often on the move.

Not only is the location flexible but also so is the distinction between work places, homes and public spaces. Additionally, working times have become flexible, with all the good and the bad that this brings.

As we are now almost always online, but seldom in our office, there is an increasing need to be able to contact people at the proper moment in time, at the correct location and with the adequate technology. This cannot be done if people do not have simple, good tools for an overview of other peoples' activities and situations. As one lab colleague explained:

“I would like [when I return to the office] to have a feeling of what has been going on while I was away and of what is happening right now; what people are present and what is going to happen...”

The approach here is to move away from collecting and displaying awareness information about individuals to collecting and displaying awareness information about a group of people working in the same premises. This will allow us to avoid privacy problems, normally generated by surveillance technology, as we do not focus on individual persons. We are not after the answer to questions like “where is X now?” or “what is she doing?” but rather to questions like “has anything happened?” or “is there anything out of the ordinary I should know about?”

For this, we collected a large number of small bits of information via sensor technology. While this is not new, our plan was to try to find the proper way of displaying this complex information to the user in a way, which will allow for ‘glances’ (while doing something else). We want the user to be the one that interprets the information and not the computer. The challenge is not how to create a good ‘prediction’, but rather how to design the ‘display’ of this complex, ample information in a simple, intuitive, clear way that will allow the user to make sense of it.

Heatmap Concept

While later we implemented a prototype of this concept in a museum environment, the original concept was thought of with work environments in mind.

The idea was to place a number of sensors in the public spaces of an office environment (corridors, kitchen, etc.). A multitude of sensor types could be used, ranging from very simple ones (motion detection, pressure sensors, etc.) to more advanced ones (webcams, Bluetooth,

etc.). All these sensors would collect information about people moving around, about a meeting room hosting a meeting, etc. The point here would be that the system would not identify who exactly was there, but would identify that someone was there.

The collected information would be integrated and based on it a heat-map of that office would be computed. The map would use colours to show current activity, as well as past activities (in a sort of fading way). The heat-map would be displayed in some public area of the office (like for example a wall at the entrance). By this the map would convey to the people coming in (co-workers, visitors, etc.) the level of current activity as well as information on past activity.

This approach is different from most previous ones in a number of respects. Firstly, it focuses on providing awareness of a group of people instead of the more common approach of trying to 'follow' individual people. Secondly, the accent in our case is on collecting simple information and displaying it in a smart, clear way. By this we leave it up to the viewer to draw the conclusions from that information, instead of trying to make the computer interpret it.

Within HeatMap we have taken the metaphor of a heat camera and adopted it to visualise both real-time and stored sensory data. A heat camera can detect the heat of existing objects or heat emitted by objects previously present. In this way, the heat camera can be used to visualize previous and existing activities.

Setting and Prototype

In order to explore this concept further on, we have developed a prototype. The goal of the prototype was to experiment with the use of different types of sensors for identifying and recording movement and activity, as well as to experiment with ways in which this information can be better presented to the user. At the same time we wanted to spark reactions and discussion from people visiting the museum about the presence of sensors around us, a presence that we can count to increase in the near future as miniature sensor networks are becoming off-the-shelf technology.

One setting was the Technical Museum in Stockholm. One of the most popular rooms of the museum is the Teknorama (Figure 6.3) where visitors, many of which are kids, can interact with different exhibits in order to experience certain physical laws commonly used in daily tools.

During our initial meetings, the museum staff raised one of the problems that they are confronted with, that of evaluation of the exhibitions that they stage. While an array of methods can be used, most of them require vast resources, mainly in the form of people's time. Additionally, because of privacy protecting laws, any form of video recording is forbidden.

We suggested the use of our Heatmap metaphor, as it would allow for a certain form of evaluation. While it would not provide clear, detailed data on the number of visitors or on their precise activities during the visit, still our approach could provide an overview of what parts of the exhibition are most popular and how that popularity evolves during the day or even weeks. Our hope was that we could provide the curators with valuable information without affecting the privacy of the individual visitors. The overview of the visitors' activity would be graphically displayed to the staff and they could then interpret those patterns in relation to the questions that they are trying to answer.



Figure 6.3 The Teknorama at the Stockholm Technical Museum.

Quite early on in the design process, we concluded that we would add a second goal to our experiment: not only was our system to be used by the staff, but we would also make an exhibit in the museum of it. This would allow us to put the system in front of the visitors and have them

also experience the sensorial information. By this, we wanted to trigger a reaction from them about sensors, privacy and all the related issues. This plan fitted nicely with the exhibition hosted in the room just next to the Teknorama where the main theme is ‘vision’. Given that sensors are a new way of ‘seeing’ the world, we felt that it was a very good place to host this Heatmap exhibit.



Figure 6.4 Heatmap visualization.

We created a 3D model of the Teknorama room, with the different exhibits, and then placed a network of sensors that covered the different areas of the room. The values of the sensors, as well as average values of the past 5 minutes, are overlaid on top of the 3D model that were projected in the adjacent room (see Figure 6.4).

Pulsating circles indicate the area surveyed by each sensor. The speed of the pulsation shows presence of activity in that given area. This activity accumulates in time and ‘heats up’ the floor below the surveyed area. If there is no activity, the heating effect decreases. In this way, we have both representations of current activities, as well as a certain ‘trace’ of activity in the past minutes.



Figure 6.5 The machine telegraph that we 'recycled'.

In order to allow for viewing of activity patterns in time, we decided to use some simple interaction that would control the time in the visualisation. We chose not to create a new interaction device, but instead to 'recycle the affordance' of an old technology. We decided to install in front of the Heatmap projection an old machine telegraph (see Figure 6.5). While not everyone knows that this type of equipment is called that, most people correctly associate it with ships where it used to be found. But more importantly for us, all people know how to interact with it when they see it. This device has a strong, clear affordance and that is exactly what we were after.

Heatmap in Use

The resulting system (Figure 6.6) was installed and was in use for a number of weeks. We have also presented the system in two technology-oriented exhibitions where visitors could interact with it.

While the use has not been evaluated by some formal means, by discussing with the people at the museum, by watching people and kids interact with the system and by talking to the visitors of the exhibitions, we could get a first round of conclusions on how people experienced the interaction with the system.

The first observation is that everyone that came in the area of the installation, upon seeing the machine telegraph, were immediately drawn to it. In that respect, choosing this artefact for interaction, instead of

some up-to-date object, has proven to be a very good design decision. After all, this installation was intended to attract people and selecting this old technology, the machine telegraph, and placing it next to very new technology, a flat screen, up-to-date 3D graphics, sensors, etc. generated that attraction factor.

Secondly, due to the inherited attributes of the machine telegraph, through its 'affordance' (Norman 2002), most people instinctively knew how to interact with it. This turned out to be the case even with children, who did not have a clue what that was, where it came from or how it should be used. No explanation was needed, no trial-and-error time from their side. They just knew that they should grab the handle and push it left or right.

While the 3D graphic on the screen did not tell people a lot about what this installation was all about, once they started moving the handle, they could immediately see the same machine telegraph on the screen (see lower left corner of Figure 6.4) with the time marked on it, suggesting the manipulation of time. This concept was for sure not immediately understood by people, but at least grownups got it after playing some time with the HeatMap. In the case of the kids, depending of course on their age, it was rather unclear how much of the concept was understood, let alone appreciated.



Figure 6.6 The Heatmap prototype.

Conclusions on HeatMap

This small experiment with sensors, even if placed in a museum setting, has allowed us to explore a number of concepts that can be applied in different other settings in relation to addressing social awareness.

Among these concepts, novel here is the way in which we shift the focus of collecting awareness information from the individual to a broader 'group'. In this way we reduce the privacy issues, but in the same time supply the users with a sense of what is going on. In a number of situations it is not necessarily relevant to know exactly who is doing what, but it is more important to know that something is going on.

The experiment has also helped us understand how sensors and sensor networks could be used as activity overview devices. The use of sensors allowed us to measure and display a heat-map, a concept generated by the Aether model.

The Heatmap we experimented with provided an ambiguous type of information display. Instead of being a problem, this is seen by us as a feature that invites experimentation, play and thinking. It also offers a novel way of considering information display, where 'being clear and informative' is replaced with 'being ambiguous and suggestive'. In certain design settings providing an ambiguous overview of the social awareness will be better and more useful than providing detailed personal information.

In the same time, the Heatmap design falls in line with the ideas of translucent technology as we, by intention, did not interfere with the sensor information, simply displaying it in a graphically attractive way to people. We left it up to them to try to understand and to interpret the information, something that people do daily, in various situations, with good results.

After this small project, we envision using the concepts experimented in Heatmap in office environments, with the goal of improving the social awareness of the people active there. It would be a new way of extending @work and it would be of interest to see how such a group-based approach would help people to have a better context of work.

6.4. Use of Aether by Other Researchers

Since the publication of the Aether model paper, a number of researchers have used the model in their theoretical approach to the problems at hand or in their system design. We find it relevant to look at these uses of the model before we continue with looking at how Aether can be used in areas that are relevant to this thesis.

A very interesting project from the University of Virginia, called the Ivanhoe Game sets high goals: "... its purpose is to use digital tools and space to reflect critically on received aesthetic works (like novels) and on the processes of critical reflection that one brings to such works." In modelling the game, Nowviskie (2003) uses the Aether model in order to "...introduce time as an additional coordinate in the awareness calculation [the one based on the Spatial Model] allowing the number or frequency of interactions and encounters with objects to figure into a computation of awareness".

This is not the only case where the time dimension of the Aether model has been put to work. In Bowers and Jää-Aro (2004) Aether was used for 'activity-oriented navigation'. The goal was to discover those spots in the VR environment where something interesting was going on, but also spots where something interesting had happened *in the near past*. For this, the authors argue for the use of the Aether extension to the Spatial Model.

A very direct use of the Aether model in a system is presented in Wegner et al. (2001). The goal there is to develop a collaborative infrastructure for mobile and wireless devices. They envision 'on the move' access to structured object spaces, regardless of the device used or of the application in a way that should allow different people to collaborate over those objects. This presents them with the challenge of having shared objects without having the possibility to enforce shared displays. In such situations, it is difficult to provide the workspace awareness needed for cooperation to happen. They turn to the notions from the Aether model that suit their needs well as their data forms a network of shared objects. They use the metaphor of a 'finger' in order to give the user control over the nimbus while the display window is the control of the focus.

Morphett and Jessop (1998) look into another interesting application area for Aether, that of semantic scoping in 3D environments, a line of thought similar to the one presented earlier on in this chapter. While we

fully describe the way in which such scoping would work, Morphet and Jessop (1998) are interested in classifying the different scoping mechanism available.

In big VR environments where the number of objects represented is huge, the system design requires a mechanism called scoping that will reduce the number of objects considered by the system for visualisation for a certain user. By reducing the number of these objects any download or rendering will be possible in real time. The problem that such scoping introduces is the risk of removing from the visualisation important objects for the person using the system. Morphet identifies four basic strategies to implement scoping: static, dynamic, semantic or hybrid.

Basically, in the first case, the VR data is predefined in a number of separate areas, often separate rooms or places in the environment.

In the second case, dynamic scoping is obtained by using some sort of calculation that will decide what objects will be part of a given scoping or not. For example, the Spatial Model can be used for such a scoping where the geographical distance combined with the nimbus and focus information will decide on what to be shown and what not.

Semantic scoping is a way in which semantic information, mainly logical relation between objects in the VR space, is used in the scoping mechanism. Here Aether is presented as an alternative strategy. While the authors do not detail how that would happen, we can see how that could happen. If we would have a VR space and we would 'superimpose' a semantic network on top of it, by using the previously defined mathematical model, it would be easy in the scoping algorithm to consider not only the geographical relations between user and VR objects but also the semantic information. In this way, a close object would be within the scoping because of the geometrical rules, while a more distant, even small object, but with a strong semantic connection to the user or to the object nearby would be selected based on the awareness percolation over Aether.

Troussov et al. (2008, 2010) use the concept of "spread of activation" in semantic networks, which is similar to our percolation mechanism. Their work combines semantic networks with text processing and they employ an advanced mathematic method, polycentric fuzzy queries, for percolation, or "spread of activation", as they term it. For them Aether is

"mutual collaborative spread of activation". 'Mutual' because it works not only from user to item, but also from item to user. 'Collaborative' because normal "spread of activation" refers to single-user environments while Aether addresses shared environments as well.

Percolation is the single most important performance issue in Aether implementations due to the large amounts of objects that need to be visited in realistic semantic networks. Along with Troussov's spread of activation, we can mention an attempt to use relational databases to perform percolation, which is suitable because databases are optimized to perform in similar time irrespective of the dataset size. The yet unpublished attempt by Cristian Bogdan⁵ provides awareness between the users of Parade (Bogdan 2008), a web-based, collaborative integrated development environment. Parade users cooperate to develop an application made of over 2.000 interrelated scripts. Such relations are registered in the semantic network and count on the order of tens of thousands. Each of the 20 users has a copy of the application, thus increasing the semantic network size twenty-fold. The percolation times over this network are under 2 seconds.

6.5. Conclusions

In this chapter we have looked at a number of application areas of the Aether model, introduced in the previous chapter. We have shown how the model can be used as a generic awareness engine in collaborative systems and how a number of useful functions of such systems can be implemented using the Aether concepts.

Using the conclusions of the Aether metrics considerations, we looked at how the model can be applied to solve a number of problems in shared VR environments. We presented how the model could be used for semantic scoping of large VR environments and how geometrical and semantic information could be combined in order to obtain better awareness relevance in shared VR environments.

We presented another area of potential use for Aether, that of self-emerging groups, and we introduced the concepts of focus-based and nimbus-based groups. In connection to these concepts we have shown that heat-maps of activity can be computed with Aether in semantic networks or in mixed VR and semantic environments.

⁵ Personal communication

We then experimented with the Heatmap concepts, suggesting an alternative way for looking at human activity, where the focus is shifted from the individual towards the group. In this way we could reduce privacy issues and could present people with ambiguous, yet interesting and relevant data. Heatmap, as the other projects in this thesis, is an example of translucent technology, where we have not attempted to model in interactive systems the human skills related to collecting, filtering and interpolating awareness information, but rather we have used digital technology to allow people to use their natural skills.

In the same experiment we also integrated up-to-date technology with a 100 year old one, the machine telegraph, by this showing that *recycling of interaction affordance* can be a useful design alternative especially for settings where the goal is to attract, to fascinate and to awaken curiosity.

We consider that this chapter has proven the potential of the Aether concept and has contributed to the discussion of some of the research questions raised in the Introduction. Part of the findings and ideas of this chapter will be reconsidered in the following, final chapter, in discussions that will lead to answering the research questions and in the conclusions where a number of implications for design will be suggested.

7. Discussion And Conclusions

The first part of this thesis looked at a number of design-oriented projects where our interest was to address the social awareness related questions raised in the beginning of the thesis. The second part has introduced Aether, a theoretical model for awareness support in CSCW systems. We have discussed its theoretical implications as well as envisioned ways of using the concepts of the model in a number of areas.

In this final chapter, we plan to look back at those projects and re-address the issues presented in the Introduction. We will use the diversity of the settings 'visited' in these projects and we will start by understanding how the settings of these projects have evolved in time, in line with the way in which computer use has changed and in line with the ever-shifting focus of HCI research.

Having the experience from the different projects and having the approach proposed in Aether, we will revisit the way in which real-life characteristics of awareness, as introduced in the first Chapter, are related to solutions in interactive systems that support social awareness. We will also re-discuss the awareness genres presented in the Introduction, looking at how our own solutions relate to the different types of approaches.

We will then use these experiences in order to revisit the research questions at hand and, by answering them, we will present implication for the design practitioner.

7.1. Discussion of Main Issues

The main projects presented in this thesis span over a range of settings. In saying that, we refer to 'setting' in a larger sense, that of the interplay of location, interactive technologies at hand, type of people involved, their relation to technology, their goals and expectations and the social norms found.

In this discussion, we will look again at the projects presented in this thesis: @work, Saxaren, Svenskwebb, Heatmap and Ajmo Splite!

Dimensions of the Settings

In order to consider the different settings, we will use a number of dimensions of these settings. While the selection of these dimensions is subjective, we have chosen those that are of relevance to our discussion on social awareness and on the other aspects that we will address later on in this chapter.

THE LOCATION: Initial HCI focus has been the workspace, be it office, factory, field. Later on the interest shifted to other locations like third places (museums, public places, etc.) and even homes.

Our projects are no exception from this. For example, @work handles the very traditional type of office location. Saxaren and Svenskwebb address in the same way workplaces, even if these have a distributed nature, when looking at the group of people involved in the design.

Heatmap took us into a museum setting, though the ideas tested here have also clear potential in office environments as well. Further out is Ajmo Splite!, where we took the interactive design out on the streets, in the middle of the city, in the very public place once called 'the Agora'.

Other researchers have investigated the complexity and the difficulty of the very personal and private space we call "home". We mention here the interLiving project (Westerlund et al. 2003; Lindquist 2007) where the goal of the design was to find ways of improving communication between generations, and Gaver's exploration (Gaver et al. 2004) of a ludic design with a digital drift table placed in people's living rooms. The sensitivity of approaching this kind of very personal space has not been captured in academic literature as vividly and charmingly as in the movie *Psalms from the Kitchen* (<http://www.imdb.com/title/tt0323872/>).

The impact of the location has direct implication on what is relevant awareness info and how it can be provided. While in workspace settings the focus of awareness is bound to stay close to working tasks, other types of spaces will need to refocus the concept on more elusive aspects of human activity.

Not surprisingly, privacy issues become a major concern. While in the Saxaren application there was almost no need for privacy control, due to the strategic location of the electronic boards in places that had an

already established privacy control pattern, in Heatmap we had discussions on whether our system does not cross legal borders related to surveillance of people in public spaces.

Working in the public environment raises also interesting design process issues, as we discovered in Ajmo Splite! Choosing the location, choosing the right time for an event or getting official permission are things for the designer to consider and to solve properly; "the work to make it work" (Bowers 1995b) will be higher and more intense in these public settings.

THE ACTOR: As in the evolution of HCI in general, our projects have witnessed the same shift of focus from 'the user', a person that uses computers, mostly for clearly defined, goal oriented, work related activities, into 'the person'. A number of researchers have challenged the concept of *user* over the years (Bannon 1991) as they felt that it did not provide a proper description of the person interacting with a system any longer, once computers and interactive devices entered other places of our life. Later on, 'the person' is the central actor, an actor without a compulsory task at hand.

While this thesis has not made a distinction, in our projects, we find "the user" mainly in the @work setting. Saxaren and Svenskwebb already show a combination of users/people who use devices not only for work, but also to explore, to socialize or just to have fun.

Heatmap becomes a clear case where there is no work, no goal at hand, no clear intention. People visiting the museum are the target, children, adults, young and old. The same is valid for the Ajmo Splite! setting, where everyone on the street is encouraged to interact and to participate and where people can also be called 'citizens'.

Another important change, at least for awareness considerations, is the fact that the 'person' becomes more and more anonymous. We have seen this transformation when we compare @work, or similar systems like Messenger (MSN), to Heatmap, where we get awareness information on what people do in museums but without knowing who they are. That was actually the intention of the solution chosen but nevertheless it points to a change in perspective.

Similarly, in Ajmo Splite!, while the system was planned to be open to everyone and it was intended to encourage everyone's participation, anonymity can provide cover for less constructive reactions, as our small

test has also shown. This leads to a fine-line discussion on democracy and control/supervision in IT based solutions for the public, a discussion even more heated when we are addressing politically loaded settings like the one we handled in Split.

THE ACTION: We have already shown that the activity the user/person is concerned with can be *work*, and hence HCI talks in terms of 'usability', 'goal', 'task', or activities like play, fun, exploration, socialising, engaging, etc. In this second case, HCI uses the term *experience design* (Brown 2004; Gaver et al. 2007).

@work, for example, was started with the design goal of helping users with their work-related activities. Saxaren and Svenskwebb do the same, but acknowledge from the beginning the need to look at other dimensions, like social interaction, play, explorations, etc. in combination with the work-oriented goals of the interaction systems.

In Heatmap and Ajmo Splate! there is a shift towards the softer type of activities: exploration, curiosity, discovery, in the case of Heatmap; social engagement, political expression, curiosity and political interaction are the key elements in Ajmo Splate!

THE TECHNOLOGY: With the evolution of computers and with the explosion of digital devices and systems, the technology considered in these projects has also evolved. As location and actor have changed, so has technology. It also worked the other way around: as technology has progressed and has entered new locations, so have actors and actions evolved.

@work and Svenskwebb are projects closer to a situation where we can talk about computer systems. Saxaren and Heatmap need another term for what they are. 'Artefact' is a generic term used, as is 'interactive devices'. Saxaren uses 'wall displays'. Heatmap integrates sensors, a network of them, with museum installations and with a 100 year old technology. Ajmo Splate! is an interesting example where common day technology (mobile phones with SMS) is combined with an artefact placed on the streets creating a 'street installation'.

TIME DIMENSION: As technology has evolved, so has the inter-connectivity of people and the time spent online. By this, we mean being connected over interactive systems and devices with others around us. In a sense, we have all moved from a 'sometimes on' context into an 'always on' situation.

@work and Svenskwebb are examples that cater to the 'sometimes on' situations. In Saxaren we found that 'always on' became an explicit request of the people using it. Heatmap and Ajmo Splate! were also considered to be always on, always sensing movement in the museum and always receiving and displaying messages from people.

STRUCTURES AND NORMS: As work is normally structured in clear organizations, those of our projects that look at work are those that need to consider the formal organizations in which that work takes place. Not surprisingly, when moving from workplace to public places, when the borders between work and social, between task and experience, between organization and communities become blurred, the rules and norms, be it official ones, social ones or technology-related ones, change and shift.

As such @work, Saxaren and Svenskwebb are strongly related to the organizations in which the people are active. Still, in Svenskwebb, only some of the people involved were formally part of the organization and as such new concepts were explored, like that of a community. Organized along other lines, in parallel or as a complement to canonical organizations, these settings raise special consideration in the design process.

Changing the focus from small groups to large communities, in certain cases communities with members who are hard to be reached, like in our Svenskwebb setting, had a serious impact on methods and approaches as well. The traditional PD methods, where one would gather groups of users in order to involve them in design, this is no longer easily done. The Svenskwebb project was such an example and the design process we chose had to carefully consider the alternative methods within our PD approach.

Heatmap and Ajmo Splate! are completely outside any organizational structure. Ajmo Splate! explores ways in which people can communicate ideas or opinions in an informal way with the leaders of the official social/political organizations. In a way, Ajmo Splate! provokes the canonical, political structures, involving the citizen in a way closer to the original idea of democracy.

Social Awareness in the Setting

Now that we have looked at the settings, we will consider the role that social awareness plays in each of these and how the different dimensions will influence the design considerations in relation to awareness.

We have seen, for example in @work and Saxaren, that social awareness, even if not called by this term, is one key ingredient in work, in general, and in knowledge work, in particular. As such, any interactive system that will address work-related collaboration will need to provide proper support for social awareness. Supporting and improving social awareness will be relevant for the success of the technology envisioned.

Social awareness is a fundamental element for the formation of communities of practice (Lave and Wenger 1991). While it is a key element in later stages of a community's life, it is also central in the initial period of setting up and shaping the community. The design of interactive systems should not only support it, but in settings such as Saxaren and in Svenskwebb, it is needed for building and developing the communities.

In Saxaren, the improved social awareness became the central goal of our design. Play and fun were used as means for social awareness building and our system had to cater for them as well, even if we were designing for a work-oriented setting. Interactive systems can, as such, prove to be interesting tools for play, fun, experiences and other socially motivated practices, even if the desired outcome is later on work-related.

In Svenskwebb we identified lack of proper social awareness as being a major obstacle in sparking a community of practice. While computer systems can help, there will be situations where real-life steps will need to be taken, in parallel with the deployment of supporting technology, in order to get the critical mass of activity and involvement needed.

In a similar way, in Ajmo Splite! we have shown how interactive systems can encourage a different type of dialogue in relation to the awareness of social and political issues. While the setting was a classic local community, technology brought another approach to social awareness and social involvement.

Revisiting Real-Life Characteristics of Awareness

In the first chapter we briefly presented the real-life characteristics of social awareness. We have used them, throughout the thesis, as a reference point when discussing certain aspects of social awareness support in our design. It is of interest here to re-examine those characteristics and to see how they relate to our projects.

Real-life awareness requires regular monitoring. This characteristic is related, in the case of interactive systems for collaboration, to the way in which social awareness information is displayed to the user.

In the @work case we had the desktop computers, intensively used by the members of the lab throughout a day, in order to provide this regular monitoring function. While initially we considered video feeds to be the simplest way for that, it later turned out that more punctual information, often in form of text or colour-coded symbols, worked well. Additionally, providing the user with a function, the 'watch' button, that handed over to the system the regular monitoring, was a needed improvement.

In the Saxaren case we considered locating the digital whiteboards in places where teachers would often pass by, in this way allowing them to simply take a short look at the screen, being able to monitor in this way what was new, thereby affording regular, peripheral monitoring. The 'regular' part of this monitoring was also reflected in their explicit request for the system to be always on.

In the Svenskwebb case, the limited time teachers could spend in front of the computer and online, turned out to be one of the problems in using the system. This case shows how lack of possibilities for regular monitoring can contribute to the demise of a system

In the Heatmap case, the system would show all the time the readings of the sensors, providing on one single screen a simple, intentionally ambiguous, view of what is going on. The sensors took over in this case the regular monitoring, in a very strict sense, while the machine telegraph allowed people to 'go back in time', in this way making it possible for them to follow activity-related information from the past.

We suggest that one way of reflecting this characteristic in interactive system design is by using *glance views*. Presenting relevant information, that needs regular monitoring, to the user, in a very accessible way, with a design that allows for fast recognition of changes, will be close to the real-life way in which people are used to monitor activity around them. In the case of systems or installations that can be placed in different locations, designers should consider what are the places that will allow frequent or regular monitoring by the users and, as done for example in our Saxaren project, designers should try to involve users in identifying the optimal location.

Real-life awareness information collecting is a peripheral activity. Awareness information collection is seldom the central activity of the user. It is, in normal situations, a secondary, or peripheral activity. This is something that interactive system design needs to consider.

A relevant question is how social awareness support can be integrated with the central functions of the system and how this support is interweaved with the daily activity of the users. As we have seen in Saxaren, for example, understanding the work pattern of the teachers and placing the new technology within the physical space and within that pattern of activity, was key to a successful solution.

Problems arise when people have to actively allocate time and effort for using such systems. In Svenskwebb users complained that this was not easy due to the nature of their work and, as such, the system was less successful.

In real-life awareness information sent out by people is a by-product of user activity, requiring no major additional attention or effort. This characteristic refers to the need to have simple mechanisms for 'sending-out' social awareness information.

In Heatmap we looked at sensors as reading devices of human activity, attempting in this way to be as close as possible to the natural awareness information generation as a by-product of activity.

In other situations, like @work, this was not easily possible but a clear motivation for the users made it possible for the system to rely on user-entered data.

Real-life awareness is bound in space and in time. These are two relevant characteristics as normally digital systems are suggested for settings where one or both of these characteristics are a problem. In distributed settings it is clear that due to the space-bound nature of real-life awareness, non-co-located people will have a problem with social awareness. In the same way, people that, due to their activity pattern, cannot interact at the same time will not be able to be aware of each other properly.

Any setting will need an analysis with respect to which of these two characteristics need support and how. In our Saxaren and Svenskwebb it was the distributed nature of the setting that led to solutions that had as prime objective the bridging of space. But in Saxaren, though teachers

would work more or less in the same time, due to the nature of their daily activity, the system needed to provide ways that would allow users to interact asynchronously. The technology we used was based on notes, left on the system, as people leave PostIt! notes on whiteboards for people to find later on.

@work was a setting where bridging space was less important, even if members of the lab would work in different locations. It was bridging of time that was relevant. People would be able to let others know their availability status and could leave messages about where they were and how they could be reached.

Heatmap uses a 'time-machine' concept to allow people to explore awareness information that is not bound in time any longer. Recorded sensor data can be viewed by going 'back in the past'. In the same time, using sensors, awareness information collected in one place can be displayed and viewed in another.

Space and awareness are also central to Ajmo Split! By bringing the discussion about the future of the city back into the very city centre, in front of any citizen passing by, we increased the visibility of those issues and of the different opinions around those issues, raising by this the awareness of people. It is due to interactive technology that it is made possible.

Humans have developed refined ways of controlling the awareness information that they 'send out'. Humans have developed advanced skills in selecting relevant information and inferring awareness information from available data. Based on these characteristics, we suggest throughout this thesis the use of translucent technologies (Bogdan and Severinson 2004). Such technologies will leave it up to the people to use their advanced skills in relation to handling awareness information.

In @work and Saxaren we have left it to the users to decide what and when information is being sent out, while in Heatmap we have presented the sensor information to people, leaving it up to them to interpret it. For this purpose, Aether offers a dedicated mechanism, based on the negotiation between interest of one side and presence/activity of the other sides, for deciding the relevance of awareness information.

Real-life awareness information is collected for unknown (but anticipated) future use. Regarding this characteristics, translucent technologies, those that will present the information to the user and let her handle selection of

relevant data, can be a solution as humans have developed over time correct expectation regarding the information that should be kept in mind for future use, based on previous experiences.

While traditional systems would implement a method that would choose the relevant information at the moment when that information would appear, Aether, for example, suggests to keep all information in the semantic network for later decision about the relevance of a certain information. This is done by the mechanism introduced by the model. Later on, if needed, garbage collection can decide, based on previous use of information, what proved to be of relevance and what would not be needed any longer.

Revisiting Awareness Genres

In the Introduction we have suggested a number of genres with regard to the different approaches in supporting awareness in interactive systems.

We find it of relevance to look at how our own systems fit into these genres and what are the most important advantages and disadvantages with each of them. In this way we provide the practitioner with an insight into understanding what type of solution might be considered in different situations and settings.

MEDIA SPACES. As already mentioned in the introduction, an assumption was that low bandwidth in communication channels lead to awareness information missing in communication. If that would be the case then a media-rich channel (e.g. video and/or audio) would ‘carry along’ also natural awareness information together with the more explicit communication. Furthermore, this would come at no extra cost as the collection of data would happen anyway and the ‘displaying’ of it would be made in a natural form to the user. Monitoring this kind of information would be for the user nothing more than the real-life counterpart.

Our @work system started with the same assumption. If we had the rich media communication tools, new at that time, we could have used them to improve the feeling of being closer together for the group we studied. In the progress of our work we started, based on user input, to add small functions next to the video link. We can notice from the evolution of the project that these smaller, simpler functions became at the end the core of the system, the media rich video link becoming just a secondary

function. While very useful for specific direct communication between two colleagues, it had in the meantime lost its social awareness related role.

While not the case in our systems, in the media space based experiments, where such systems were placed in more public spaces, privacy became, as one would expect, a serious concern of the researchers. While a number of techniques have been suggested and tested, the issue of finding the proper balance between privacy and providing the information needed by others for interaction remains without clear-cut answers.

Another critique to these types of systems is that they address only the space related dimension. In other words, these media rich communication channels do create a bridge in space, simply connecting two different, and sometimes far apart, locations. But due to the synchronous nature of video and audio these approaches do not handle the bridging of time, as needed in certain contexts. As such, media rich systems will be useful, as long as the other issues raised are properly addressed, only in those settings where providing awareness over time is of no relevance and where the major need is to cater for the bridging of space.

If we look at the Svenskwebb project, we clearly see that the Swedish teachers abroad needed tools that would properly cover both the bridging of space but, at least as important, also the bridging of time. In such a context video could help for direct communication but it would do little to add to the awareness support.

Involving rich media for larger groups also poses a problem related to how all communication channels are to be presented to the user. In desktop-based solutions, where economy of screen space is an issue for any application, it does not take a lot of video links to become an inconvenience to the user. As identified in the discussion of the real life awareness, the regular monitoring needs to be a permanent, peripheral activity, but if the solution provided demands a large part of the user's screen, sooner rather than later, the user will drop the application or it will land beneath other windows, with no possibility for the user to do the monitoring.

These solutions tend to work only in settings where bridging space is the essential function of the interactive system. It will also stay viable in

cases where a small number of sites or people are connected via such technologies. Where the solutions work, they do provide very rich communication and excellent contexts for developing the social awareness of those involved.

MESSAGING SYSTEMS. Our @work system can be classified under this heading. While the initial intention was to use video for improved social awareness, at the end we came to the realisation that other types of functionality were of greater importance for awareness maintenance. The resulting system was based on small bits of textual and graphic information collected and displayed in various alternatives.

Not very different in principle, even if addressing a basically 'desktop computer free' environment, Saxaren also focuses on using small messages, this time in the form of the classical 'PostIts'. Again, we found that in that setting this was considered enough in order to improve the social awareness between the teachers located on different islands of the Stockholm archipelago.

The key difference between @work, as well as a number of commercial solutions, and Saxaren is the nature of the messages that can be transmitted. In Saxaren, teachers had at their disposal a very free form, based on handwriting and drawing. It was exactly this rich format that allowed them to be very expressive in their communication, by this developing their social awareness of each other.

Sending small messages, by SMS or by recording them onsite, turned to be the approach also for the Ajmo Splite! project. The goal of placing the discussion of controversial issues back into the central piazza of the city, the old agora, used as such also messages for raising the awareness regarding these issues.

This type of solution to social awareness will work best in small groups and will provide good support for loose social interaction. It has proven to be of a more limited use in work-related situations. On the other hand, this sort of functionality can be an interesting addition to collaboration software that needs improved social awareness between users.

This genre has been in the meantime superseded by, or has evolved into, online social environments, like Facebook, Twitter, etc. Such systems are still based on small text messages, but in the meantime complex functionality has been added. Besides proper support for loose social

awareness, such systems prove to be the modern ground for marketing and other commercial uses. Privacy issues are still present and such systems do not always cope properly with them, as seen in the latest privacy problems of Facebook.

SHARED VR ENVIRONMENTS. For shared VR spaces, a number of awareness models have been suggested, most importantly the Spatial Model. As presented earlier in the thesis, the model suggests an elegant mechanism where both the interest of one side, as well as the presence and/or activity of the other side, will generate the level of awareness needed between the two sides.

The Aether model moves the Spatial Model into semantic networks, as described. It also allows for a nice mixture of VR environments and semantic networks, with the potential, as highlighted earlier, of allowing the introduction of the time dimension in the VR environments, as well as allowing semantic based connections in the VR world, linking two different VR locations by virtue of some semantic relation. By this, the Aether model can be a convenient approach to improving on the VR environment limitations that we previously identified.

AWARENESS MODULES. These refer to parts or modules of more generic shared interactive systems. It is the case of applications that do not have social awareness as the main design goal but where awareness support is provided as an important additional function in the system. This is important mainly in application where collaboration, be it for work or for fun, is needed and encouraged.

The Aether model is our proposed way to handle such modules in collaborative applications. Based on a very flexible concept, it can be implemented at system level as an engine. It becomes then a fundamental feature of the application and can simplify the implementation of the various awareness functionality, as well as related functions, as seen in Chapter 6.

Aether will integrate perfectly in applications that are based on semantic networks or that are VR based with additional semantic network layers, as discussed in the previous chapter.

PHYSICAL INTERFACES. We have experimented with such technologies, especially in our Heatmap project. Using sensors is a tempting alternative for collecting awareness information. As in real-life situations, such information is a by-product of general human activity and sensors can

pick up this information without any effort from the side of the persons involved. This is, however, not without concerns, as we have discussed before.

Our Aether model can be also used with such technologies, as the multitude of sensors, devices or gizmos, normally forms networks of information. Social awareness can be 'negotiated' within such networks based on the interest of certain parties and the activity of other parties, in flexible ways. Self-emerging groups are also very well supported in the concepts of Aether and sensor/device networks, with ever-changing topographies, can be interesting application areas for these mechanisms.

On methods and approaches

Addressing social awareness, and awareness in general, brings special consideration in the use of methods. The cause for this is the fact that social awareness issues are sometimes so subtle, that people almost never consider such issues in an explicit way.

Traditional 'specification'-based methods often fail to consider support for social awareness, as has been shown in research literature earlier (Dourish and Belotti 1992; Schmidt 2002). Users/people will tend to notice awareness or issues around awareness normally only when support for it is missing in interactive systems or when it fails.

Sanders and Dandavate (1999) defined a conceptual model of understanding the users' needs, activity and desires. Figure 7.1 presents an adaptation of Sanders' model suggested by Westerlund (2009), where the left pyramid defines the levels of the users actions, while the right pyramid defines the nature of the information that one can 'collect' out of the respective action. In the middle, a number of methods are listed that can be used in relation to the different levels of user activity.

What we can say is that social awareness concerns and issues will rarely be in the 'explicit' area. They will tend to be partly in the 'observable' and partly in the 'latent' area of the pyramid. As identified here, methods from the Participatory Design (PD) approach will be those that will be able to 'collect' the relevant information from the users: ethnographically inspired observation, participatory workshops, user-involved deployment, rapid prototyping, etc.

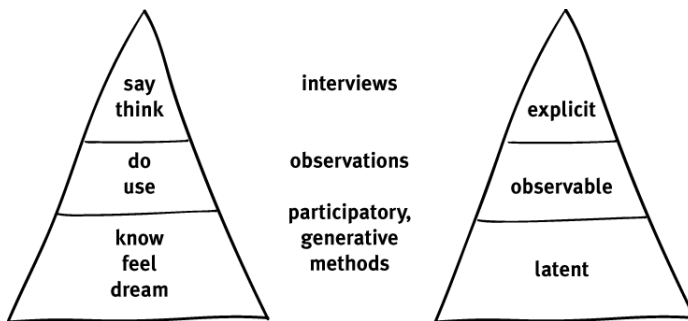


Figure 7.1 Understanding the user's needs a conceptual model (Westerlund)

Besides this, the designer should also properly consider his/her role in the use of these methods. Besides the ideas expressed by the user, regardless of the format of the method used, the designer should assume an active role of interpreting that information, comparing it with a number of reference considerations, like those suggested in this thesis.

PD methodology is also in line with the suggestion for translucent technologies, as in these methods and technologies the focus is on letting the user be an expert. In the first case, she would be an expert designer, while in the second, she would be an expert in handling social awareness information.

7.2. Revisiting the Research Questions

We started off the thesis by laying out a number of research questions around and about social awareness. We intend to use this section to revisit those questions, in order to answer them by showing how our different projects have addressed these questions.

The goal here is to be able to suggest alternatives and approaches for the practitioner, more than to find generic answers to these questions, that one has to bare in mind whenever faced with the challenge of designing interactive systems in a social context.

What information is relevant for social awareness and how could it be collected by the system?

Our projects show, in their diversity, the fact that it is hard to answer the first part of this question in a generic way. In @work, availability information seemed to be key for the social awareness of the lab members.

In Saxaren, we have seen that we could not clearly identify the information that contributed to social awareness, but it was the way in which our open communication technology was put to use by the teachers that had the relevant contribution. We could almost say that, in this case, it was not the content of the communication that was relevant, but the form of this communication, a form that allowed for experimentation, fun and other informal, unstructured messages to be passed around.

In Svenskwebb, it was the information about who the other teachers were, who had been online since the last visit, what new contributions to the forum or book reviews had been made, and "who has been online".

In Heatmap, we replaced the more concrete information with an ambiguous sensor reading: clues that showed that 'something' was going on, without being able to know what, how, by whom. Nor had we clear ideas how this would be interpreted by the people playing with the system.

In Ajmo Split!, as we moved to a politically related experiment, it was important to identify information about controversial projects or concepts of the administrative apparatus, as only such issues would have triggered the reaction and involvement of the population, as was our design goal.

An approach used in @work, which can be used by other practitioners in trying to answer this question in the given situation, is to look at the existing physical objects or existing technologies available to people in the setting. Often these objects, like the physical whiteboard on the corridors of our lab, indicate the way people manage social awareness information and can be very relevant in defining new interactive systems that also need to properly support social awareness.

Looking at the second part of the questions, which is related to the way in which the relevant social awareness information is collected, we have seen that this is somewhat more concrete to answer. Basically, as already seen in the Introduction and in other parts of this thesis, we have three major alternatives: (a) *automatic* collection of data, (b) *user entered* data and (c) *in-between*, or mixed, methods.

Automatic collection of data offers the simplest way to collect the information, at least from the perspective of the user. No special effort from her side is needed and, in most cases, information can be collected

automatically without interfering with her other activities. A problem normally encountered with this approach is the privacy concern. We will detail this concern when revisiting the next research question.

The user-entered data reduces the privacy concern, at least in most cases, as it will be up to the user to decide what information, at what time and to whom to disclose about herself. The disadvantage here is that, in most of the situations, there is no motivation for the user to spend time and effort in entering this information, as she is not the direct beneficiary of this information, but it is the other people involved in the system. As already shown, counting on the user to input/update this kind of information is futile, when there is no clear reward for the effort required.

In most modern systems developers try to find some middle ground between these two alternatives so that advantages and disadvantages are balanced out. So it will also be in our case, for each project presented there being a specific solution, adapted to the design goal and circumstances we encountered in each setting.

In @work, we used such a combination of user-entered information, an approach used in the first prototype, with information collected automatically, but from other systems and technologies used by our users to signal their availability. This has reduced the effort of the user, has created another technology of choice for him/her, but without collecting any information that was not introduced and controlled by the user. As we will see further down, when we look at privacy, we had to address the need of the user to be able to provide one set of information for the group of colleagues, where privacy concerns are smaller, and another set of information to the people outside the formal group.

Another finding from the @work experience is the motivation of the users for entering and updating social awareness information: the professional need to keep up an up-to-date web page, with all relevant information about projects, publications, etc. Without this motivation, such a system, that requires time and effort, despite of certain cross-platform automatic data collection, would most probably not have worked.

In Saxaren, as we had not decided on specific information that would have been needed to be collected, no automatic data collection was possible. Our prototype allowed users to pass info to each other in an

open way and it was up to users to express in those messages not only clear work-related info, but also the social complement to that. We have seen in Chapter 4 how this worked. This solution falls somehow outside the three alternatives mentioned above, but very much in line with translucent technologies already discussed. In this case, the technology is transparent with regard to the information collected or transmitted over it, the task of entering information, choosing what needs to be transmitted and interpreting it is left completely to the users.

Svenskwebb is a case where automatic collection of user data, at least regarding the teachers' activity within the system, is possible and straightforward as the system is accessible only to the selected group so privacy issues are secondary. Still, we have seen in this project that social norms can be different in different parts of the world and can inhibit communication and collaboration even in a system restricted to a group of colleagues. So the social context outside the system will play a role even where apparently certain solutions seem appropriate.

Heatmap deals with collecting data in a way that might seem too simplistic and too 'brutal': it uses sensors to record information. No effort is required from the people as their normal movement and activity will trigger the sensor to record data. Still, we have not done this without concern to privacy. Playing with sensor collecting data, but keeping the information very ambiguous, without a clear interpretation of it, is a conscious experiment we make with trying to find other ways of sensing human activity.

Sensors and devices that we use or surround us, filled with different types of sensors, are becoming more and more a part of our lives and are being integrated within our surroundings a ubiquitous way (Weiser 1993). Using them will be tempting for interactive systems, but using them in ways that do not cross socially accepted privacy boundaries will continue to be tricky. Even if not referred to in terms of social awareness, or awareness in a more generic way, the issues presented in this thesis will continue to play a relevant role in technologies and systems that include sensors as information collectors.

The Aether model presented in this thesis offers a novel approach to handling the different research questions. In the case of the collection of information, Aether is flexible and open, without defining how data is gathered to form the semantic network.

Aether offers a new approach in regard to the problem of identifying the relevant awareness information. Traditional systems would choose from the beginning the information that seems to be relevant. Still, there are situations where this is not possible and only later on one can know what is becoming of relevance and what not. This is a result of the fact that even in real-life awareness, information is collected *for future, unknown use*. In the Aether approach, it is the negotiation of one party's interest (focus) and the other parties' activity (nimbus) that will highlight the relevant awareness information. All this happens not at the moment in which the information is collected but at a later moment in time. That is, relevance is identified at the moment of *future use* and not at the moment when information is created/collected.

How can awareness data collection that includes information on people be balanced with respect to privacy and integrity?

In addressing this question in a design situation, one should consider at least three circles of privacy: (a) the person, (b) the 'inside' group, normally those people closer to the person in the given context and (c) the 'outside' people/group(s). Certain settings might have additional such circles of privacy, but assuming the three is normally enough to start with.

We have been less concerned in our projects with the boundary between (a) and (b), as that boundary is clearly identifiable in most situations. Still, designers should have the awareness of that boundary, as no system will cross it without running the risk of being so 'uncomfortable' to people that they will refuse to use it.

More important, in our experiences, has been the border between (b) and (c), between the people 'inside' and the people 'outside'. We have approached this line in various ways, as discussed in each chapter. Firstly, the designer has to identify this distinction, of the 'inside' and 'outside' and, secondly, the designer will need to find ways to properly support it in the considered system.

In @work, given the work-related situation, with clear institutional relations, we have found a rather natural boundary, defined specifically by the institutional rules of the setting. Mainly, people that are officially part of the laboratory were considered by all colleagues to be 'inside', while students, as a general rule, were considered to be 'outsiders'. A less clear line was also identified and it regarded people from outside the

formal structure of the lab, for example people from other departments, but very involved in work/research with people from within the laboratory. These were 'inside' the group for some members of the lab and 'outside' the group for others.

The solution used in @work was to use two sets of data, one to be shown to people within the group and the other set of data to be seen by people outside the group. The two sets had overlapping information, to be shown to all. By filling in the information in those sets, the user would control what the more privileged people from within the group would see and what would be available to everyone outside this group.

In Saxaren, we easily identified the people within the group, as this was along institutional lines. Furthermore, we could say that our system tried to transform the existing situation, with one small group of colleagues in each unit, into a situation with one bigger group of colleagues across the units of the school.

Considering the nature of the interactive system suggested, we, together with the users, decided that the system would be accessible only to those 'inside' the group. While pupils in the schools are a very important and natural part of the life of teachers, even if we briefly contemplated integrating them in some form in the system, at the end, it was decided to keep the system strictly to the teachers.

Normal IT system design would have considered some sort of access control mechanism. In our given situation, this would have gone against an important goal of our design, that is, the simplicity of the interaction suggested. As such we have *reused the privacy affordance of the physical space* from the schools studied. By properly placing the Saxaren whiteboards in places that are normally only accessible to teachers, be it physically or by the social norms of the school, we could skip adding in the system a layer of access control that would have complicated the interaction between schools and would have inhibited the natural use of the system.

In terms of information transmitted from one side to the other, it was up to each person to decide what would be fine in terms of, for example, privacy. Inspired by the informality of the system and knowing that information is normally accessible only to colleagues, messages tended to be, as seen, of a more personal nature than normal work-related communication, the existing social norms being the only mechanism of selection of sensitive data.

In Svenskwebb, the 'inside' group was also identified in a natural way. While only some of the teachers of Swedish abroad are formally connected to the Swedish Institute (SI), most of them are in touch with SI. The membership in the group was defined by the profession, that is, members were supposed to be those that are teaching Swedish, in one form or another, at universities abroad.

In this project, we had a very similar discussion to the one in Saxaren, regarding the inclusion in the system of the students of these teachers. At the end we made the same decision, though we wonder if the project might not have evolved better if we had included the students in it. Being based on a more standard, web-based technology, using normal access control was considered fine and we have not seen any problems in that respect.

One finding in the project was that, even if the system was available only for other teachers, some of them felt that they could not post questions that might have indicated problems that they were facing. They continued to use email for their problems privately to the support staff at the Swedish Institute. The identified cause was the local culture of certain countries/universities that, opposite to West-European practices, consider discussion of ones problems as signs of weakness or lack of skills.

Heatmap offers a completely different approach to awareness and privacy. Instead of focusing, as most systems, at the awareness of individuals, the experiment tried to look at ways of capturing and displaying information about groups of people. Its goal was to show that 'something' is happening, but not 'what', that 'someone' is active, but not 'who'.

By shifting the focus from individual to group, from specific to general, from precise to ambiguous, we have removed, or at least reduced, the privacy sensitivity. It is often that people are fine just with this type of information, as this is the case anyway in the physical environments. People, as we have seen, have developed advanced skills in transforming this general, ambiguous information, coupled with context-related social awareness, into relevant social awareness information. Interestingly, in this approach, the fact that privacy is 'controlled' by the existence of social awareness, as this generic, ambiguous, information will not be understood by those who, not being part of the social group, do not

have the needed social awareness of understanding and inferring the available information.

As we have experimented with the concept in a museum, one could argue that such a setting would not require people to infer specific information and that it served only an explorative, amusement-related purpose. We would argue that the concept can be clearly applied to work-related settings or other settings where specific awareness information is needed.

We have seen that, in approaching this question, we have looked at groups and especially at identifying boundaries of those groups. Another approach suggested in a number of places in the thesis, is that of *self-emerging groups*. While considered by previous researchers, we found that the theoretical model of awareness brought forward in this thesis provides the theoretical concepts and tools for implementing these types of groups.

Aether can be used to handle issues regarding groups. Based on the flexible mechanism discussed, it can identify dynamic, self-emerging groups, as detailed in Chapter 6. This removes the need to define from the beginning groups in a static way, removes the need for memberships, etc. Groups would be able to emerge, based on the model suggested by us, either when people would have common focus, that is would have common interests, or when people would have common nimbus, that is would have related presence or activity. Additionally, as the awareness is seen in Aether as a distance, it has continuous values, allowing for identifying concentric levels of 'belonging' to such a self-emerging group. In doing this Aether brings a seamless integration of the 'inside' and 'outside' the group.

Aether could also be used to handle privacy issues in a flexible way. We have discussed in section 6.1 how the model can be used for implementing access control methods that are novel compared to the standard methods, simplifying access control but offering the needed privacy protection. Another important part in the model, in relation to privacy, is the fact that those implementing the model can decide how much control should be handed over to the user. This is done by deciding in the implementation how much of the focus, nimbus and aura control is done automatically and how much would be under the direct control of the user. In this way Aether proves to be a model that can be

used for implementing a variety of solutions to the privacy issues discussed here.

How could the collected data be filtered, interpreted and/or transformed in order to obtain information relevant to social awareness?

The social awareness data that is collected by the system (regardless of how) normally needs a certain degree of filtering, interpretation or transformation in order to obtain information that is relevant to the people using the system.

While more traditional solutions used to let the information system do this job, our approach has been, in most projects, that of a 'translucent' technology, that is, a minimal interfering of the system. We consider that humans are much better equipped to handle such interpretation of data, as these skills are anyway used daily by people in their physical environment. We see the interactive system to be more of the collector and transmitter of data and not the interpreter of it.

This is in line with experiments done by, for example Bogdan and Severinson (2004), where 'open' sensor technologies are deployed in people's homes, with easy possibility for each one to describe what each sensor would mean. This puts the user in charge in "explaining" to the others how information should be interpreted, instead of letting the system make the (possibly wrong) assumptions. This interplay of letting the user 'give meaning' to data and, at the other end, letting the users 'make something out' from the data, is the approach we suggest for awareness, in general, and social awareness, in particular.

In @work, no information is interpreted or filtered by the system, but it is up to the user to describe his/her situation and availability.

In Saxaren, as we have seen, we have focused on a very transparent technology, one that does not structure at all the information flow. It is fully up to the user to decide what needs to be written/drawn on the system, along the social rules of the familiar white-board.

In Heatmap, we took the explicit design decision of not interpreting the data at all. The focus has rather been of finding an interesting way of presenting this data, so that we spark the curiosity of the people using the system in trying to figure out something relevant from the information displayed.

In Ajmo Splite!, all messages were randomly displayed by the system, with no selection process involved. Any filtering here of information would have suggested censorship and would have gone against the goal of the interactive system, that of allowing and encouraging people to speak freely about sensitive city politics issues.

Aether offers a generic solution to the problem of interpreting, filtering and displaying awareness information. Based on the negotiated solution of the Spatial Model, Aether offers the same flexible, open solution to semantic network based applications. As such, filtering and interpretation are replaced with the calculation of awareness relevance, based on the level of interest (focus) and level of activity/presence (nimbus). This calculation is done at the moment of use, that is, not in the moment in which information is generated but in every moment. By this the model identifies what awareness information is relevant for a user, in that respective moment, given the information context of the application.

What information is to be presented to the user, when and how?

Once social awareness information has been collected, possibly filtered and/or interpreted, this information needs to be displayed to the other people in the system. Especially when the group is larger, this might become difficult. The limitations here are normally connected to information overload. One does not want to miss relevant data, but at the same time, people do not like to be overwhelmed with useless information either.

Traditional systems use either a push mechanism, where information that was considered relevant by the system is being displayed to the user, or a pull mechanism, where the user asks for that information that she finds of importance in the moment chosen by her.

As we have seen that awareness-related information is not something one follows actively, but rather is part of a regular monitoring process, the pull mechanism has been used with poor results. It is the push mechanism that is normally preferred, even if it has other disadvantages, mainly the difficulty of designing a system that will be able to correctly identify what the relevant awareness information is for a given user and what the proper moment is for it to be displayed.

An in-between solution is one that uses a subscription mechanism. The person chooses what she is interested in and the system will display information related to the expressed interest.

For example, @work uses such a mechanism, where people can activate a 'watch' function in relation to those colleagues where changes in availability are of importance or urgency. Similar solutions exist nowadays in most messaging applications in form of lists of friends, etc.

The way in which information is displayed is of equal importance. With information overload already present for most people, with limited display areas in most cases, the way in which awareness info is presented will have an impact on its usability.

We suggest for this the use of *glance views*, views that allow for a fast overview of information in the shortest possible time. We have used this throughout our projects. For example, in @work we prepared a web-based view, not unlike the physical sign-in board of the lab, where all people with their most important availability information are presented on one page. In Saxaren, it is the way in which all messages are shown all the time, so that people, even when just passing by the system, will notice any addition or change in this communication channel. In Svenskwebb, we gathered in the first page of the web-based system all relevant changes since the last visit of the respective teacher, be it new messages in the forum, new comments on books or new members that have joined. This allows even those very busy to be up to date with what is new, with minimal time required to be spent using the system.

Glance views are closely connected, in the case of social awareness, with the real-life regular monitoring of the others' activities. In order for the user to do this regular monitoring, she has to be able to see the relevant information as easy as possible and with almost no special effort.

Heatmap simply displays in an attractive form all sensor data. What we also experimented with was the introduction of the time factor. The controller available to the people makes it a sort of time machine, even if this is a bit ambiguous, at least at the beginning. It was of interest to see the reaction and the interpretation people would bring to an unusual way of looking at information. We are used to synchronous information and 'going back' in time is not an intuitive activity for our mind.

This ambiguous, yet logical way of displaying data is in line with Gaver et al. (2003), where ambiguity is seen as a resource for design that "... can

also be intriguing, mysterious and delightful. By impelling people to interpret situations for themselves, it encourages them to start grappling conceptually with systems and their context, and thus, to establish deeper and more personal relations with the meanings offered by those systems.”

In order to encourage exploration, we took the liberty to combine in Heatmap recent technologies like sensors, flat screens and 3D animation with a 100 year old technology. It has a strong interaction affordance, everyone knowing intuitively how to play with it. By choosing to reuse this affordance of the machine telegraph, we have avoided providing a solution that has not been proved and we have generated the curiosity in the museum's visitors to try and to explore our system.

An interesting approach to displaying information targeted to raise social awareness is found in Ajmo Splitel, where the sensitive problems of the city are physically re-positioned where they were traditionally discussed: in the centre of the city, in the Agora. It is here where technology brings its contribution by transforming an intangible debate into a visible discussion, by this sparking awareness and a reaction in people.

Another relevant approach for defining what information might be of interest to different users is the one suggested by the Spatial Model, where relevance of awareness information is a negotiated combination of one's interest (focus) and one's presence or activity (nimbus).

By offering a framework in which synchronous and asynchronous awareness can be supported equally, Aether ‘deconstructs’ this distinction in a unified approach. This is a powerful conclusion because the distinction between synchronous and asynchronous is used so very commonly - often as a way of distinguishing between different kinds of system. While synchronous-asynchronous may often be a clear distinction at system levels where different communication protocols are discussed, perhaps we should not crudely transpose the distinction so that it classifies different types of awareness, still less different types of cooperative work. What matters to cooperative work as it is experienced, we suggest, is the integration of different streams of work, which may be on many different time scales and show varying degrees of relevance to the matter at hand. Having a level of system architecture where different forms of awareness can all be supported together seems most appropriate to this image.

Implications for Design

All these research questions can be connected in a more generic one:

How can social awareness issues be approached in interactive systems design?

Based on the findings in this thesis, we would suggest structuring the design approach based on the taxonomies already proposed and discussed:

- **DIMENSIONS OF THE SETTINGS:** Get a better understanding of the situation by considering the dimensions and the social awareness implications of the dimensions of the setting, as described in this chapter.
- **CONSIDER GENRES OF AWARENESS SUPPORT:** When technologies are to be chosen for the given project, consider the genres available and the advantages and disadvantages posed by each of these types of solutions, in line with our earlier discussion.
- **CONSIDER REAL-LIFE AWARENESS CHARACTERISTICS:** Look at the setting and the design goal at hand and see what real-life characteristics could be used and which would need system support. A good design will try to stay as close as possible to the real-life characteristics of social awareness, as we have also seen in our projects and as we have discussed earlier on.

Besides these generic frames, we have already mentioned a number of considerations that will be of use to designers that want to consider proper social awareness support in their interactive system design:

TRANSLUCENT TECHNOLOGIES: What we suggest is to try to implement technologies that do not try to replace the human skills in transmitting, collecting and interpreting social awareness information, but, rather the opposite, the system should provide the user with the needed functionality in which it should be up to her to use the naturally developed social skills in handling these issues. Not only does the designer avoid entering into complicated design problems, but also the probability that the resulting system will feel more natural in use for the people will increase, leading to a better and/or faster acceptance of the new system.

GLANCE VIEWS: In identifying proper ways of displaying social awareness information, designers can consider glance views as ways in which relevant information is presented in a simple, but visible way. We have

shown in this thesis a number of applications of this concept and we think that it should be applied with this type of information.

FROM INSIDE TO OUTSIDE: Designers will need to discover the different circles of people involved in the specific setting. Identifying the boundaries between these groups is as important as is the decision regarding which groups to be included in the system designed and in what way.

MOVE FROM PERSON TO GROUP: If privacy issues turn out to be complicated to be solved in the given setting, consider moving away from information regarding the individual persons and see if the same could be achieved by using more 'anonymous' types of information, like, for example, groups of people.

NEGOTIATED AWARENESS: As discussed, identifying what part of the data is relevant social awareness information for the people using a system can be complicated. . Where there are no hard-coded methods for identifying relevance we suggest to consider in the design solutions 'negotiated' approaches, as proposed in the Spatial Model and in our Aether model.

PLAY AS A SOCIAL AWARENESS ENABLER: In situations where social awareness is not present or is very limited, introducing play, exploration and fun into interactive systems will prove to be strong social awareness builders. Designers can experiment in the given setting, as long as this does not go against local social norms, and they can check if this could be a viable approach.

AMBIGUITY AS FEATURE: As used in some of our projects, or in our 'person to group' approach to privacy, ambiguity can be considered as a feature for social awareness support, especially in relation to play, fun and experimentation.

REUSE OF AFFORDANCE: Often there is no need to reinvent solutions that have been proven in time. Designers should not only look at the real-life characteristics, but should also have an open eye to existing technologies, physical objects and physical spaces. Social awareness related affordance of them might allow for simple and interesting integration with new interactive systems. As we have seen, reusing privacy affordance of space might be a good solution, especially in cases where simplicity of the technology is key. Affordance of older technology or older objects can

also be reused, as seen in Heatmap, especially when the design goal includes raising curiosity and questioning.

PARTICIPATORY DESIGN: As we have argued, PD is very well suited in addressing social awareness aspects in the design process, mainly because of the fact that social awareness issues are of a tacit nature, users normally being unable to express directly the related needs. PD has proven in our case to work well not only in the initial, explorative part of the design process, but also in the design, testing and deployment of the suggested interactive systems.

7.3. Contribution of the Thesis

As we have seen in this thesis social awareness is an important part in collaborative interactive systems and, while more is understood about it, it remains a complex issue to be addressed by designer.

The thesis contributes to the field of HCI and of awareness research in a number of ways. To start with, one of the projects presented here, @work, is responsible for *introducing the concept of social awareness*.

Based on the investigations from this thesis, another contribution, useful for interactive system design practitioners, is the *systematization of social awareness on various criteria* (see section 7.1). Using *the dimensions of the setting, the real-life characteristics of awareness* and/or *awareness genres* will be practical tools for the designer as well as theoretical frameworks for considering social awareness.

We also contribute by identifying a number of *implications for social awareness design* and by providing *insights into use of design method* in relation to the focus of the thesis (see previous section).

Having done some of our projects in communities' settings, the thesis also contributes with a relevant *investigation of social awareness in diverse communities*.

Having done some of our projects in communities' settings, the thesis will also contribute with a relevant *investigation of social awareness in diverse communities* (see Chapter 4 and final chapter).

Last but not least, the thesis contributes with a theoretical model called *Aether* that proposes a model of handling awareness in semantic networks as well as in hybrid systems where shared VR environments are augmented with semantic information (see Chapter 5).

We have discussed in detail the model and its application areas, so we will only briefly list here the major properties and possibilities of the model:

- It offers a generic solution for supporting awareness at system level;
- It offers a flexible approach to issues regarding data collection, filtering and interpretation by allowing the solutions to emerge out of a negotiated interplay of one's interest and the other ones' activity;
- It provides a novel approach to semantic network applications where normally awareness is handled with event-based mechanisms;
- It softens the distinction between synchronous and asynchronous as time is just another dimension in Aether;
- It allows for integration of shared VR environments and semantic information, as geometrical space is a subspace of the Aether space (see section 5.3).

These properties of the Aether model make it a flexible and promising theoretical and practical tool for researchers and practitioners in handling social awareness in particular and awareness in general. Applications of Aether can be found in other areas of design and research, as described in Chapter 6.

The long (for practical reasons) research study period gave us the opportunity to assess the impact of some of the contributions of this thesis as citation numbers. The highest impact in the HCI community lies with the @work and the social awareness concept (135 citations⁶) presented in Chapter 3. The second highest lies with the Aether model (78 citations).

⁶ According to Google Scholar

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