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Technology Support for Relation Work in Video Meetings

The Design, Implementation and Evaluation of SideBar

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Chapter 1

Introduction

Nowadays, more and more work is being carried out in a distributed fashion. Instead of working together in a collocated group, people at different locations collaborate using software tools to connect to each other. Distributed collaboration however, introduces a number of problems related to the distance between people. In general, the distance in distributed collaboration is divided in to three categories; physical, temporal, and cultural. These three distances in turn can complicate the development on several different levels. The problems of distributed collaboration have been divided in to 3 categories of collaboration challenges; communication, coordination and control all of which are affected by the introduction of distance. Furthermore, distance have shown to influence willingness to cooperate and be persuaded [3] and trust [2]. So, while distributed work might yield great benefit for companies, it introduces a set of collaboration challenges as well that cannot be ignored. These benefits and problems also make distributed collaboration an interesting research field – indeed companies can benefit greatly from distributing work but a number of potential pitfalls are also introduced.

1.1 Video Meetings and Relation Work

Central to the distributed collaboration is the video meeting. As a high bandwidth communication channel and an often used tool in the collaboration, the video meeting serves as one of the most important points of communication. The importance of the video meeting and it's position as the *"next best ting after face-to-face meetings"* [4] makes it an interesting setting to study. Specifically, it is interesting to look at how the video meeting can be improved, or used in different ways, to further strengthen its utility. Previous research have analyzed and modified the traditional videoconference setup as we know it, to investigate potential ways of improving it (cf. [9][19][26]). Yet, none of this research considers the fact that global actors without any connections might be brought together in the video meeting and expected to collaborate. Efficient communication does not appear solely as a product of high bandwidth communication media. The best conditions for good communication to take place, is if connections between the involved actors exist [16]. The work involved in creating connections is part of the work conceptualized by Bjørn and Christensen as *relation work* [1].

Relation work explains the work involved in creating the social-technical connections between people and people, people and artifacts, and artifacts and artifacts and is needed for other work to take place. The distribution of people, artifacts and work in distributed collaboration challenges actors in this relation work.

This report examines the concept of relation work and present the design, implementation, and evaluation of SideBar – a videoconferencing system designed to facilitate relation work in distributed video meetings. The main feature of SideBar is a tablet application providing an interactive mirrored video from the videoconference. Tapping the image of a person in the interactive video feed brings up a personal profile for that person. This profile contains personal and professional information and access to a communication backchannel. Figure 1.1 shows an illustration of SideBar. The video conference setup is extended with tablet computers that meeting participants use to seek information about each other and for backchannel communication.

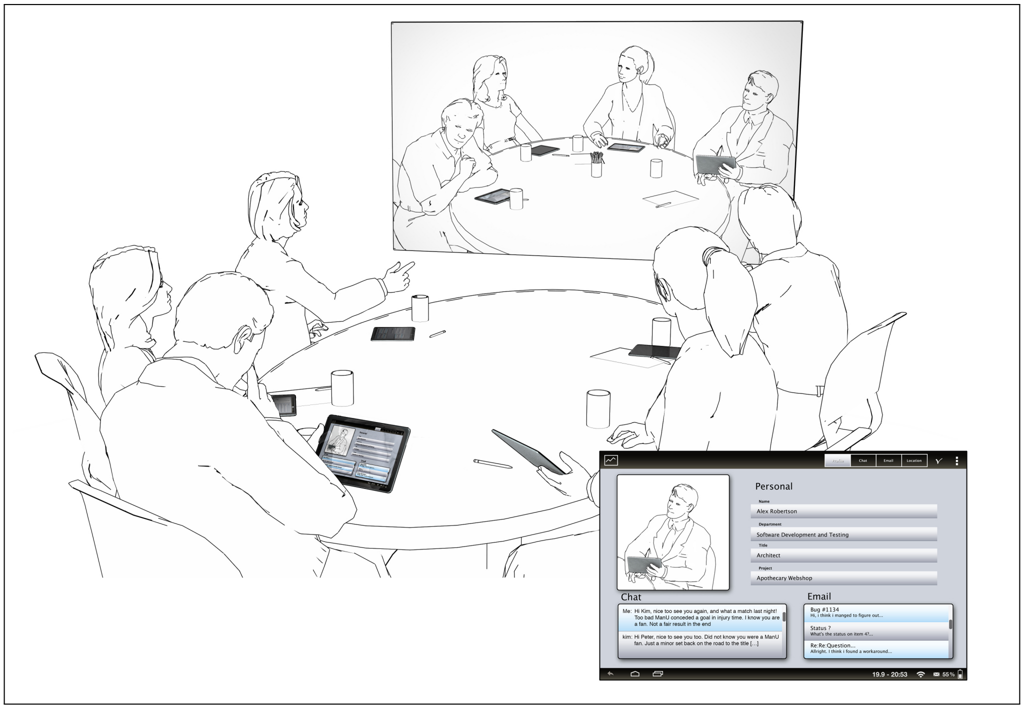


Figure 1.1: A drawing of the vision of SideBar - participants in a meeting connect with remote actors through the SideBar application running on tablets.

1.2 Problem statement

Relation Work is a fairly new concept, and to our knowledge technologies targeted specifically at supporting this has yet not been designed. This report sets out to explore the possibilities for designing technologies that support global actors in the efforts involved in relation work. As we will see, relation work is conducted (or should be) throughout a collaboration and is not restricted to a specific time or space. This report however focusses on relation work within the videoconference.

The problem statement that this work seeks to answer thus is as follows:

How do we design and build technologies that facilitate relation work?

1.3 Goals and methods

To answer this research question, we have defined the following goals that will be met throughout the report:

- G1 **An explanation and thorough understanding of relation work.** Before we go in to designing for relation work, we will try to carefully explain the concept. To date, relation work is only described in a single article by Bjørn and Christensen [1]. Furthermore, we explain how relation work in enacted within and how it affects the video meeting. The outcome will be an understanding of the concept of relation work.
- G2 **A discussion of the design of relation work supporting technologies.** To aid distributed actors in the process of relation work we present SideBar. The outcome is a design based on a hypothesis of designing for relation work and refined in a series of design workshops.

G3 **An implementation and evaluation of the SideBar** SideBar is a videoconferencing technology prototype that supports relation work in distributed video meetings. The outcome will be a discussion based on the implementation and evaluation on the feasibility of SideBar as a relation work supporting technology.

Relation work is a concept that deals with some of the problems on distributed collaboration however throughout this report we draw on examples from global software development (GSD). As a specific instances of global collaboration the GSD examples will help exemplify the work presented.

1.4 Results

SideBar was evaluated in a feasibility study with students and employees at the IT University of Copenhagen. The participants of the evaluation found SideBar useful as a meeting tool supporting relation work. Most notably, was the use of an interactive video feed and the communication backchannel. Based on the design, implementation and evaluation of SideBar, this report proposes three design dimensions relevant to the design of relation work support tools; *relational context awareness*, *relation building and sharing*, and *relationship maintenance*.

1.5 Overview

The remainder of this report is structured as follows;

In Chapter 2 the context and background is laid out. The chapter looks at the video meeting, and how the lack of connections between people has a consequence for collaboration. The work involved in creating these connections have been theorized in the concept relation work. This chapter will give a thorough explanation of the concept. Furthermore this chapter will give a more detailed explanation of the connections between video meeting and relation work. This chapter will meet the goal **G1**.

In Chapter 3 we explain related work. Specifically, we will focus on meeting supporting technologies. As the notion of relation work is fairly new, and to our knowledge, no technologies supporting relation work have been designed yet, the related work outlines more general meeting support tools within the fields of HCI and CSCW.

Following, in Chapter 4 we draw on the insights of the theoretical account to motivate the design of SideBar. This chapter will explain the thoughts behind the design and the design process leading to the final design of SideBar. The chapter will meet the goal **G2**.

In Chapter 5 the implementation of SideBar is explained. SideBar is composed of several systems which are all explained; the SideBar App, the Tracking Client image processing application, the Relation Server web server application, and the Registration App.

Chapter 6 explains the evaluation of SideBar, how it was conducted, and what results were obtained.

Chapter 7 discusses the results from the evaluation and seeks to draw the important findings learned from the work. This chapter also discusses the findings in relation to the design decisions made and the theoretical aspects of relation work. Chapter 5, 6 and 7 will meet goal **G3**.

Finally, Chapter 8 concludes this report and points in directions for future work.

Chapter 2

Background

In distributed collaboration, remote actors work together to accomplish a task. The distribution of work allows several people in several locations to work collaboratively without having to meet in the same location. While this way of working opens up opportunities for new collaborations, the distances between actors also introduce a range of problems. In general, the distances in global collaboration can be divided in to three; physical, temporal, and cultural. These three distances in turn can complicate a collaboration on several different levels and have been shown to influence willingness to cooperate and be persuaded [3], trust [2] and even project completion time [7].

Distributed collaboration is a general term describing collaboration between distributed actors. This term is very broad and covers everything from engineering to design or production. To exemplify we briefly explain one instance of distributed collaboration; global software development.

2.0.1 Global Software Development

Global software development (GSD) refers to the concept in which the development of a software product is distributed over several geographically different development locations and thus requires a high level of collaboration between developers in these different locations. GSD has been a growing market since the late 1980s, and can help a development process in different ways [21]

Lower development costs By moving (parts of) the development of a software system to other countries, development costs might be lower. Compared to North America and Western Europe, areas like Asia, Africa, Eastern Europe and South America in general have lower wages. This can help cut the expenses of a project by moving working hours to these lower-wage countries.

Around the clock development: By having production on a project in several different areas of the world, development might follow the sun leaving very little time of the day where the project is not being worked on. For example, a project can be developed in Europe, Asia and North America in a matter where by the end of a day in one region, the work is being taken over in another region at the beginning of their day.

Use of experts Making use of GSD allows a company to hire personal in different countries. This enables companies to look for and hire labor in several different locations increasing the number of potential experts available. Local market knowledge: Having development centers in different countries allows a company to more effectively gain knowledge about the markets within which the centers are located. The can help a country penetrate new markets.

While GSD might yield great benefit for companies, it introduces a set of collaboration challenges and issues, for example strategic, cultural, communication, knowledge management, project management and technical issues [8]. The benefits and problems make GSD an interesting research field - indeed companies can benefit greatly from GSD but with GSD, a number of potential pitfalls are also introduced. The advantages and challenges associated with GSD very well illustrates the general nature of distributed collaboration; there exists a number of tradeoffs that need to be considered when distributing work over geographically dispersed sites.

2.1 Relation Work

One of the problems related to global collaboration is the fact that people and artifacts are not connected in the same way as in collocated collaboration. The lack of awareness and shared coordinative artifacts in distributed collaboration requires actors to engage in extra work to archive these connections.

In the paper "Relation Work: Creating Socio-Technical Connections in Global Engineering", Bjørn and Christensen set out to understand what challenges the performance of distributed collaboration [1]. More specifically, they ask *"What got lost when we took away the local spatial arrangements supporting awareness and the use of coordinative artefacts?"* [1, p. 138]. Their answer to this question is, that geographically dispersed teams lose the networks of interconnected people and artifacts. Compared to a collocated team, the distributed team is not in the same way connected in one cooperative human electronic network. This challenge requires distributed actors to engage in a new type of work. The work that establishes the socio-technical connections in the corporative network that we know from collocated settings and that is needed for other types of work to take place. They name this kind of work *relation work*.

Relation work denotes the efforts involved in creating the socio-technical connections between people and people, people and artifacts, and artifacts and artifacts needed to form a coherent network [1]. These connection are needed in the collaboration and form a basic prerequisite for other types of work to take place. The concept thus seeks to deal with the fact that interconnected networks of people and artifacts are less frequent in distributed settings as their creation is challenged by the distances between actors. The "socio-technical" aspect implies, that there is a social dimension to relation work (such as creating personal connections and ties) and a technical (such as establishing a networked communication channel).

The challenges associated with relation work in distributed collaboration are closely coupled with the lack of awareness and coordinative artifacts. In collocated settings, the awareness of people and the use of coordinative artifacts helps create and maintain the socio-technical connections. The collocation of people allows groups to form within which strong personal connections exist while the use of shared artifacts provide a strong tool for aligning work. The connections are harder to achieve in a distributed setting, and it is exactly these strategies for alignment of work that are challenged in distributed collaboration and these challenges that call for relation work to take place in a much different way than in the geographically collocated work arrangement.

At a glance, relation work might seem like a special instance of articulation work [23]. It turns out however, that while relation work and articulation work look alike, they should not be taken as the same. Instead, the two concepts can be seen as parallel processes that both constitute some of the overhead work in a collaboration; the distinction though, is the kind of work. As Bjørn and Christensen put it *"In articulation work, communication is done to achieve an agreement as to who does what, where, and when, whereas relation work is done to achieve the right configuration of a network of people and things [...]"* [1, p. 139]. While both concepts try to explain the overhead work associated with collaborative work, relation work thus is focussed with *relational* aspects of collaborative work while articulation work is focussed with *coordinative* aspects. Relation work and articulation work are however tightly linked; as relation work is needed for other work to take place, it entails that relation work is also needed even before articulation work can take place. The correct configuration of people and artifacts - as a result of relation work - thus needs to be in place before articulation work can coordinate the actual work.

2.1.1 Relation Work in Practice

Bjørn and Christensen put forth three examples of relation work from their study of a war room in a global engineering company [1]. Their study involved an engineering company with a Danish and an Indian office. The specific point of collaboration investigated was a war room. The war room included a video conference setup that was used to connect the two rooms. During their observations of these war room meetings, Bjørn and Christensen observed several instances of relation work or effects of relation work. They describe three types of relation work; connecting places, connecting people, and connecting artifacts.

Connecting Places Ways of communicating must be established between distributed locations to allow collaboration to take place. The relation work in this process involves setting up communication equipment and making a connection between the locations. Furthermore, the relation work needed to connect places becomes particularly visible when technology breaks down. For example, if the internet connection breaks, the work involves identifying the problem, fixing the problem, and informing other locations what problems have arisen. This was observed in the war room where a technology breakdown caused a meeting to be delayed without the remote site knowing why. Clearly, this is not needed in a collocated setting; collaboration between actors can begin work without having to establish these connections.

Connecting People People must feel connected to each other for collaboration to unfold efficiently. Bjørn and Christensen observed that war room meetings facilitated by people that did not know the names of remote participants happened to be a lot more noisy and unstructured than meetings facilitated by experienced people. They explain these observations with the amount of relation work that had gone on prior to the meetings. The experienced meeting facilitators knew all participants before hand as a result of relation work. This allowed for smoother meetings where questions were easily addressed at the right people. Meeting facilitators without this knowledge due to less relation work had a harder time managing the meetings.

Connecting Artifacts The war room in the study included a poster on which tasks were represented as post-it notes. During meetings, any problems regarding these tasks we noted down on other post-it notes and assigned to people. The post-it note with the problems and the name of the assigned person was then attached to the task. As this poster existed at the Indian war room, assigning tasks to a Danish person was challenging. Two approaches - and instances of relation work - were observed. The first involved an Indian person making a task visible for a Dane by reading it out loud and holding it close to the camera connecting the two sites. This is an example of the relation work needed to create a connection between a person and an artifact. The second involved duplicating the poster so it also existed at the Danish site. This approach required a manual syntonization process where updates to the poster at one location was communicated to someone at the other location who could then update that poster. This last approach is a good example of the relation work needed to create and maintain artifact-to-artifact relations. Later, it was observed that a Dane had forgotten to attend to one of the assigned tasks. This indicated that the lack of awareness of the task challenged the specific person-to-artifact connection.

The three examples demonstrate very well the relation work needed in global collaboration. While to date only Bjørn and Christensens paper describes relation work, turning to previous research we might reveal examples of relation work or the lack thereof. Take for example the paper "Distance, dependencies, and delay in a global collaboration" from 2001 by Herbsleb et. al [7]. They report on a study on dependancies and time delays in global software development. While the work proceeds the proposal of relation work by years, the results from the study seem to underpin the notion of relation work quite well. An interesting finding of the study shows, that size of personal communication networks was much larger locally than distributed. That is, there was a significant difference between the self-reported size of personal communication networks in the local site compared to the remote site. Indeed this finding follows the consequences of distributed work from a relation work perspective; with the distribution of work, the personal networks that exist in a local setting can only be achieved globally by means of explicit relation work. Another finding of the study was that people are less likely to help out a remote coworker, although they don't perceive themselves being less helpful. This finding could also be caused by the weaker or non-existing connections the actors between.

2.2 Video Meetings

To overcome the challenges associated with collaborative and distributed collaborative work, different software tools can be used. In GSD, for example, code is shared using code repositories like subversion or git, design and architecture artifacts and project management documents can be shared on content management platforms like Microsoft Sharepoint, and communication can be done over email, instant messaging and through video meetings.

There is no doubt that the video meeting is a fundamental concept in global collaboration - and indeed one could argue that it is the video meeting that allows for such distribution of work. This realization also serves as motivation to examine the video meeting from a research perspective. If the meeting is important - or even - necessary for global collaboration to take place, it is well worth looking at any shortcomings compared to traditional collocated meetings, or to see if the meeting can be improved.

2.2.1 Information Richness

In computer mediated communication, technologies have been classified by their information bandwidth. Draft and Lengel, for example propose the Media Richness Theory that is used to classify communication mediums according to their ability to exchange information; a high exchange medium is rich whereas a low exchange medium is lean [4]. Figure 2.1 shows a classification of often used communication mediums rated by their media richness.

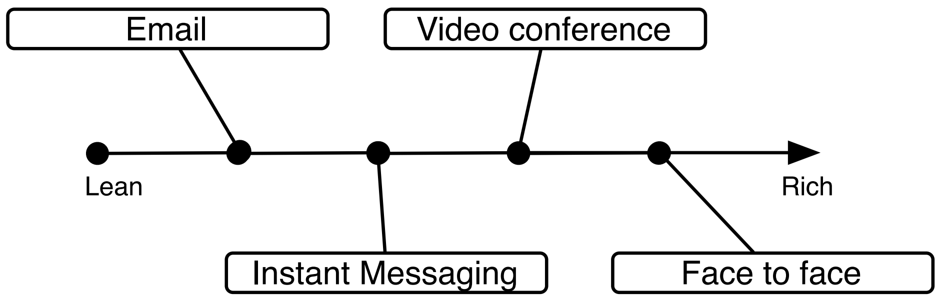


Figure 2.1: Different communication media afford different media richness.

The video meeting is – according to the Media Richness Theory – the next best thing only surpassed by the actual face-to-face meeting. This importance of video meetings calls for an investigation in to what kinds of problems associated with global collaboration might be addressed in the meeting. The video meetings position in the media richness spectrum makes it an natural starting point for several aspects of research within distributed collaboration. If we want to support phenomena that seem to occur naturally in a collocated environment in distributed collaboration, the video meeting might be the first place to start. As the technology carries the highest communication bandwidth, it is thus a well suited starting point for novel communication and collaboration technologies. Once research have focussed on the video meeting, the lessons learned might then be then be transferred to other areas and technologies.

2.3 Putting It All Together

Global collaboration faces many challenges associated with the distribution of people and work. One such challenge is the fact that distributed actors have to engage in relation work. Relation work is an ongoing process where connections between people and artifacts are constantly changed and renegotiated to form the networks needed in order for other work to take place. The challenge lies in the fact that the relation work have to be done explicitly before other types of work can take place. While this kind of work is important in many aspects of collaborative work it is interesting to investigate relation work in video meetings for two reasons; *(i)* the effectiveness of communication depends (partly) on the connections between communicating actors, and *(ii)* the high bandwidth of the video medium might provide a good starting point for supporting relation work. We explain these two points more in detail in the following.

2.3.1 Communication and Connectedness

Nardi opens her paper "Beyond Bandwidth: Dimensions of Connection in Interpersonal Communication" by arguing that *"To communicate with easy, we must come to feel connected to each other . . . "* [16, p. 91]. It is hence crucial for good communication to take place that people can feel connected. Indeed, if we look back at the examples from Bjørn and Christensen's paper, it turns out that relation work manifests itself within the video meeting - or rather, the lack of connections as a result of no relation work shows itself in the meeting [1]. This lack of connections between people as a consequence of lack of relation work can show itself in a video meeting by issues in communication. People, for example, might have difficulties addressing each others as they do not know each others name, or other might not join the conversation due to lack of knowledge about the rest of the participants. This exemplifies the need for relation work - the connections as created by relation work need to exist for the communication to be effective.

2.3.2 Video Meetings and Relation Work

While the lack of relation work might have an impact on the meeting, relation work on the other hand is also conducted within the video meeting. Before the video technology is connected, collated people might engage in relation work and discuss informal matters, waiting for actual meeting to begin. Likewise, during technology breakdowns, small opportunities for collocated people to engage in relation work with each other exist. The problem here is, that while relation work is conducted in the video meeting locally between actors, it is not being done distributed across the sites. So, while the connections between people are needed, they are not necessarily created, and can thus hinder an effective meeting to take place (and subsequent the further collaboration). As argued earlier, the video meeting due to its high communication bandwidth a good place to start investigating support for relation work. The meeting provides us with a setting that is as close as possible to the face-to-face meeting.

The video meeting thus suffers from lack of relation work while also being a setting within which relation work is conducted. Meanwhile the video meeting constitutes an important collaboration and communication interface between remote actors and is seen as an essential in distributed collaboration.

To summarize, the video meeting is central to global collaboration – it forms the communication channel with the highest bandwidth between distributed actors, and is used extensively in all aspects of the global work. Meanwhile, the meetings also suffer from one of the problems of global collaboration; the lack of personal connections as a result of lack of opportunities for relation work. Through the rest of this report, we explore these areas to give an answer to the research question; *How can technology support relation work in distributed video meetings*.

Chapter 3

Related Work

Before discussing the design of technology supporting relation work this chapter covers relevant related work concerning technology support for video meetings. The notion of relation work is fairly new and to our knowledge no technology has been designed with this concept as a specific perspective. Instead, this chapter presents a more broad view on the literature describing video meetings. In particular, we are interested in how the traditional video conferencing setup with one camera and one screen have been modified or extended to improve its functionality. The goal of SideBar as presented in Figure 4 is to improve video meetings by allowing people to interact on a social level. This chapter therefore presents literature that try to improve human aspects in video meetings.

3.1 Technologies for Video Meetings

The literature on video meetings is vast and spans from research in capture-and-access over social dynamics to tracking of people and objects. The focus of this report is on how technology can improve personal connections in video meetings, so the focus of this chapter is on technologies that seek to support people in connecting to each other during video meetings.

Different technologies can be used to support the video meeting, but one interesting approach is how to support all the information that is not necessarily transmitted by the video and audio. The usual video meeting setup of camera, display and microphone has been carefully designed to record, transmit and play video and audio from the meeting. This video and audio however - despite being categorized as rich media channels - occlude some parts of the meeting (e.g. everything out of the view of the camera or too low for the microphone) and cannot include other parts (like e.g. eye-contact). So while the setups might try to mimic a large shared meeting space, the fact is, that the video conference remains a different setting than the collocated meeting.

A large amount of work have gone into looking at the possibilities for supporting e.g. eye-contact and gaze or non-verbal communication and body-language in video meetings. These approaches all seek to include aspects of a meeting that are somehow excluded by the video-meeting. In this sense, these projects are interesting to look at in the context of relation work within meetings. Relation work – like non-verbal communication – happens at collocated sites without it being noticed, but is excluded by the video. It is thus interesting to look at how some of the aspects of a meeting that have been lost when transitioning to distributed meetings have been studied and supported.

It is important to note that different kinds of video meetings exist, and that they cannot necessarily be treated the same in relation to technologies. The related works on supporting video meetings, in general, can be divided in to four categories of meetings that vary in terms of the type of meeting they address and the level of complexity and type technology of the setup used:

1. **The personal meeting system:** The personal meeting is a video meeting between two people using a desktop, laptop or a tablet to meet using video and audio. The setup is simple as it requires only consumer-available software and hardware. This kind has been made widely available to a lot of people with the development of

high speed internet and the availability of dedicated video communication software like Skype[1].

2. **The video conference system:** The video conference is the setup where one large screen with an attached camera is used to facilitate many-to-many meetings. This setup is often seen in companies that need distributed groups of people to connect and meet.

3. **The telepresence system:** Telepresence systems are systems that have been tuned to improve the spatial aspects of the meeting compared to the traditional videoconference setup. This usually involves a setup that has been designed to send and receive high quality video and audio using several screens, cameras and microphones or setups that are altered significantly compared to the video conference system by e.g. changing the shape of the video screens.

4. **The social proxy system:** Social proxies represent a remote participant through an embodied system that can usually be easily moved around. The remote participant is thus represented as a physical device that uses video, microphone and screen to communicate with the meeting.

The following presents relevant related work for each of these four categories. The borders between the categories are not always clear, and we have tried to position work in the right category based on the framing of the authors. The main reason for this division is to paint a clear picture of the fact that video meeting technologies differ depending on the type of meeting they support.

3.1.1 Personal Meetings

The personal meeting systems are those that run on a normal consumer grade computer like a desktop or laptop and use standard web-cameras or similar. This kind of teleconferencing has become very widespread with the availability of appropriate software like Skype. Some research have gone in to looking at how to improve the personal video conference without changing the setup to require special hardware not available or affordable to end users.

To account for the lack of eye-context as a result of the displacement of screen and camera, Kuster et. al. developed an algorithm to correct frames during video conferences [12]. Each frame in the video feed is analyzed and corrected by repositioning the image to make it seem like the user is looking at the screen rather than the camera. No evaluation of the system is presented, but they demonstrate an interesting take on how to create eye-contact in video conferencing.

Figure 3.1: Frames in the video stream are combined from the live image of the remote participants face and a static background, using head tracking of the viewer to position the face and create a pseudo-3D effect. *Image taken from [6].*

Harrison and Hudson also use image processing to change the video of a home video conference setup [6]. They present a pseudo-3D video system for single user setups that uses a single camera to create a feeling of 3D. The system segments frames from the video stream by extracting the person from the background. The image of the user and a static image of the background is sent to the receiver where the system recomposes the frame by superimposing the image of the user on to the background. Using a head tracker at the receiver side, the image can be recombined to create a pseudo-3D feeling using only a standard webcam. Figure 3.1 shows the video as the viewer is leaning left,

[1] `http://skype.com`

centered, and leaning right - depending on the position of the viewer, the frames are constructed differently creating a sense of 3D. They provide no evaluation of the system but, again, this work is an interesting approach to improve the richness of personal video conferencing without changing the simple setup.

3.1.2 Video Conference

Much research have gone in to supporting transmission of non-verbal cues in video meetings. Video conference setups might not effectively transmit eye-contact, body language, pointing gestures etc. due to the placement of the video equipment. In a study of video conference setups, Nguyen and Canny conclude that video setups that include the upper body of people as opposed to systems that only capture the image of the face, have a positive result on the level of trust and empathy between the actors [18]. They suggest to design video conference systems that preserve body-language cues and gaze. Nguyen and Canny also present MultiView [17] a video conference setup where several camera are used to preserve spacial faithfulness. They compare the setup to a more traditional setup with only a single camera and find that the multi-camera setup improves trust in a group-to-group meeting. They conclude that these results comes from the fact that the multi-camera setup does not introduce spacial distortions of nonverbal cues. Slovók et. al. also explore the level of trust in different group-to-group video conferencing setups and find that a combination of personal displays and individual streams of each participant contributed to a higher level of trust development compared to traditional setups [22]. Similar findings were suggested by Grayson and Anderson who argue that the perception of proximity in video conferencing is linked to the zoom of the camera [5].

Another important non-verbal cue that might be lost in video conferencing is eye-contact. The displacement between camera and video conference screen means that eye contact is not always preserved. When a person is looking at the screen she's not looking at the camera and vice versa.

MAJIC by Okada et. al. is an early example of a video conference setup that has been designed to give the feeling of "sitting together" in a meeting [19]. The system uses large curved displays upon which life-size video of remote participants are projected. Furthermore, the cameras of the system are places behind semitransparent screens to avoid the displacement of screens and cameras that disrupts eye-contact and gaze. They don't present an evaluation of the system but report of general satisfaction with the system by people using it to play a game of poker at a fair.

The GAZE-2 system by Vertegall et. al. [26] is a group video system that seeks to transmit eye-contact in video conferences. Using several cameras and an eye-tracker per setup, the system ensures parallax-free transmission of eye contact. Always choosing the camera towards which the user is looking and rotating the onscreen videos of participants in the meeting towards each other, the system tries to simulate the gaze and eye contact that is usually lost in video conferencing. The approach is an interesting take on video conferencing, but the work does not present any evaluation of the system. Figure 3.2 shows the UI of GAZE-2 where the focus of attention from the group is on the leftmost participant.

Jenkin et. al. present eyeView [9], a video conferencing system that uses eye tracking to resize individual video windows based on looking behavior. By scaling the individual videos of participants based on the collective focus of the group, the system tries to keep focus on the current speaker (towards which the group attention should be focussed) while keeping an overview of all participants though scaled down videos of them. The system thus constantly resizes the individual videos based on group focus so the larger window will be that of the person in focus while other participants' windows will be smaller. eyeView also features an interesting opportunity for users to engage in side conversations. By looking at the video of a team member and pressing space, a side conversation is initiated and the focus of the system (both video and audio) shifts from the group focus to a 1-on-1 conversation. The latter feature is especially interesting from a relation work point of view. As we shall see, an obstacle for engaging in distributed relation work during video meetings is the lack of opportunity for entering side conversations.

Finnally, Junuzovic et. al. explore the option of replacing the conference video feed with an animated scene with avatars representing the people in the meeting [10]. Using a Microsoft Kinect to track people, an animated 3D representation of a meeting room is constructed in which avatars representing meeting participants move as tracked by the Kinects. The evaluation of the system showed that the cartoonish style of avatars and the unstable tracking of people raised concerns amongst the participants as to the extend that the system could be used for serious business meetings. When asked about a future and improved version of the system though the participants responded positive.

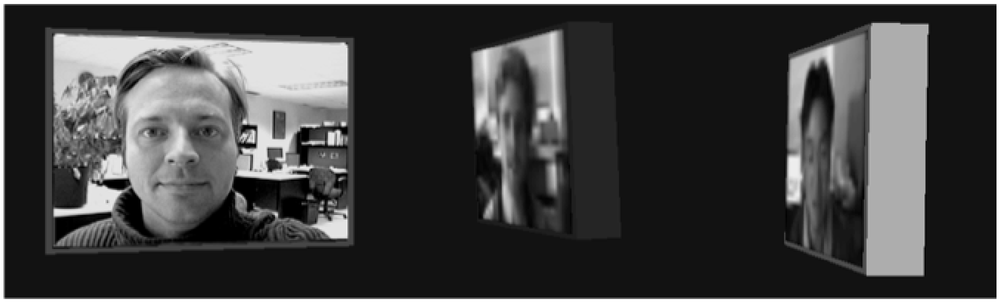


Figure 3.2: GAZE-2 scales and rotates video to convey gaze direction. The focus of the participants are on the person on the left. *Image taken from [26].*

All these studies point in the direction, that a traditional video meeting setup where only video and audio is transmitted between sites might be improved. The nature of human collaboration includes other clues such as non-verbal communication, gaze and eye-contact, and social context – all of which can be improved by changing or extending the video conference setup. As a consequence, carefully designing video conferencing systems can have a positive effect on the meetings.

3.1.3 Telepresence

Telepresence systems differ from the video conferencing systems in the sense that they radically change the setup of the equipment. The telepresence system thus might not look like the video conferencing systems that we know of.

Nakinishi et. al. study how zooming of cameras and moving of displays can help enhance social telepresence by enhancing the effects of distributed actors moving towards each other [15]. They built a system that is capable of moving the physical display to show movement of the remote participant. They evaluate the system and compare it to two other methods of showing movement of the remote actor; by having the person move and by zooming of the camera. They found that both zoom and movable displays will enhance the effect of people moving in videos and can enhance the social telepresence of distributed actors.

TeleHuman is a system by Kim et. al. that radically changes the physical construction of a videoconferencing setup [11]. TeleHuman is a 3D videoconference system that supports 360° motion parallax and a stereoscopic 3D display. The setup of TeleHuman is a 170cm tall cylindrical screen with a 3D projector inside, Microsoft Kinects for tracking, and 3D stereographic glasses. Figure 3.3 shows the TeleHuman setup: video of a remote participant is captured in 3D and projected inside the cylinder screen to give a feeling of a life-size person. The system is evaluated in 3 modes; 2D where the 2D image of the remote participant is projected onto the cylinder, 2D + parallax where the 2D projection follows the viewer around the cylinder, and 3D + parallax where the viewer wears 3D glasses to give the effect that the remote participant is standing inside the cylinder. The evaluation of the three modes suggests that 3D and motion parallax mode increases the users sense of social presence and improves the ability to asses gaze and body language cues.

LiveMask is another telepresence system that changes the shape of the video conference setup to include more information than the traditional setup [14]. LiveMask consist of a screen that is shaped like a real human face. The screen is based on a 3D scan of a face, and live video of that person is projected onto the screen. The screen is motorized and is able to pan, tilt and roll based on head tracking of the remote user, thus mimicking a real head. The evaluation of LiveMask focusses on its ability to convey gaze and is compared to using a traditional flat screen. They conclude that LiveMask is more correctly transmits gaze direction than the traditional video setup.

3.1.4 Social Proxy

The last category of video systems is social proxies. A social proxy is a device that represents a remote person and thus acts as a stand-in of a person at remote location and its purpose is to bring a feeling of the physical presence of

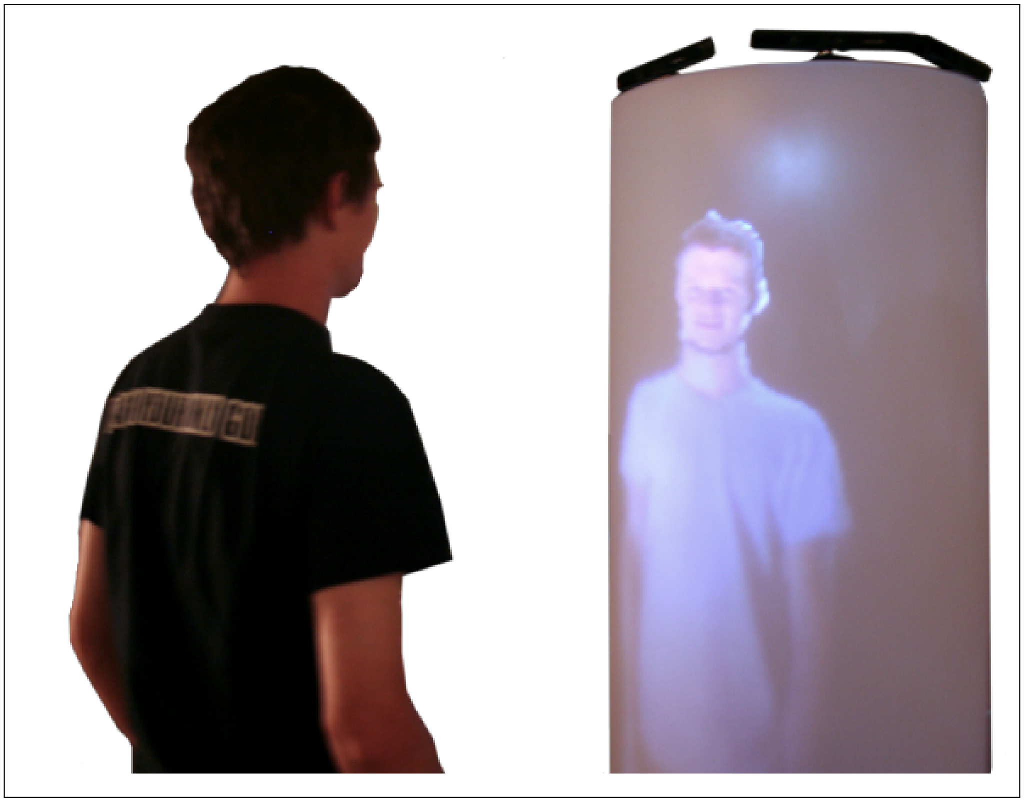


Figure 3.3: The TeleHuman system projects life-size video of a remote participant on a cylindrical screen. *Image taken from [11].*

the remote person that the proxy represents. In video meetings for example, a meeting participant might participate through a video or audio link. Traditional video meeting setups however, focus on connecting spaces not people and this kind of communication setup does not include many aspects of the social sphere of that person. In particular, there is no embodied representation of the person and the presence of the person is simply that as transmitted by the video or audio link. Social proxies try to convey some of the lost social presence of people in a distributed work environment by representing the person in a tangible embodied manner. The focus thus shifts from connecting places to connecting people - an approach very interesting from a relation work point of view.

Hydra [20] is an example of an early social proxy (although the term social proxy is coined much later). Instead of combining images from multiple actors in a video meeting by using a picture-in-picture approach, Hydra uses a dedicated device for each remote meeting participant. These devices - called Hydra Units - each contain a small monitor, camera and loudspeaker. A meeting at a given location is thus attended by a number of people and a number if Hydra Units representing remote participants. The setup allows for a better exchange of eye-contact as people turn to hydra units to talks to a specific person, and the feeling of social presence as each participant is represented by the tangible Hydra Unit.

Embodied Social Proxy (ESP) by Velonia et. al. [25] is an attempt to include the social context of a remote team member. The scenario described in the paper is that where a team (the hub) is collocated and needs to collaborate with a single distant participant (the satellite). The satellite is represented by the ESP - a device quite similar to the Hydra Unit. The ESP contains a screen, cameras and microphone however it is mounted on on wheels and can be moved around the workspace. Figure 3.4 shows an ESP in a meeting situation. The ESP is connected through the internet to the satellite, and is fed video and audio from the ESP. The satellite, sitting e.g. at home is also filmed and the video and audio is streamed to the ESP. Furthermore, when the ESP screen is not used to transmit video of the satellite, awareness information gathered from e.g. a calendar is shown instead. The study of a deployment of in a work setting suggests that the ESP increased the remote actors' ability to participate in the meeting and that it – over time improved the social connections towards the satellite.

Figure 3.4: A satellite attends the meeting through an ESP. *Image taken from [25].*

The Time Travel Proxy by Tang et. al. [24] builds upon the principles of ESP to allow a remote participant to participate in (or rather contribute to) a meeting, however in an asynchronous manner. The proxy – a touch enabled tablet – can be used to prerecord messages that the remote participant wants to be played at the meeting. Each message is a video recording of the participant and is labelled with a title. At the meeting, the participants can select the messages to be played and then discuss them. These discussion as well as other comments from the meeting, are recorded on the tablet for the remote participant to see and hear at a later stage. While the system is partly designed simply to allow for these asynchronous video meetings, it also incorporates the social aspect through the embodiment of the tablet.

3.2 Comparison of existing systems

The study of existing technologies show that much work have gone in to designing videoconference systems that carry more information than the traditional conference setup. In general, the focus have been on transmitting eye-contact and gaze information and body language and non-verbal cues. Work have also been done to give a strengthened feeling of social presence to remote participants by representing these participants as embodied proxies in the meeting.

Table 3.1 shows a comparison of the features of the different system mentioned. The features of the systems have been generalized to the following categories:

- **System:** The name of the system. In case the system does not have a name, the authors of the paper describing the system are used instead.
- **Type:** The type of system as described in Section 3.1. The following abbreviations are used; *PM*: the personal meeting system, *CM*: the conference meeting system, *TP*: the telepresence system, *SP*: the social proxy.
- **Gaze:** Systems that seek to convey gaze or eye-contact information are checked in this category.
- **Body:** Systems that seek to convey body language information are checked in this category.
- **Spacial:** Systems that seek to convey spacial information are checked in this category.

Study	Type	Gaze	Body	Spatial	Social
Kuster et. al. [12]	PM		●		
Harrison [6]	PM			●	
Nguyen [18]	CM				
MultiView [17]	CM		●		
MAJIC [19]	CM	●			●
GAZE-2 [26]	CM	●			
eyeView [9]	CM	●			
Junuzovic [10]	CM			●	●
Nakanishi [15]	TP				●
TeleHuman [11]	TP	●	●		●
LiveMask [14]	TP	●			
Hydra [20]	SP			●	
ESP [25]	SP			●	●
Time Travel Proxy [24]	SP			●	●

Table 3.1: Comparison of features in different meeting conference systems.

- **Social:** Systems that seek to improve social presence between participants are checked in this category.

3.3 Summary

While no work to date describes technologies supporting relation work, in general, the related work in the field of video meetings show some interesting findings. First of all, traditional video conference setups do not support important non-verbal cues very well. These cues include eye-contact, gaze direction and non-verbal communication. Changing the traditional video conference setup however can help communicate this information and increase trust, empathy, and social presence. Furthermore, the use of social proxies in the workspace and in meetings have shown to have an positive effect towards the feeling of social presence towards a remote participant.

One of the most interesting things in relation to this report is the fact that the related works within the field of video meetings as described here, either assume people to know each other before hand or do not consider the problems that might arise when people do not. While the projects deal with some of the limitations of the video meetings, they do not deal with the fact that these connections need to be made before articulation work and actual work can take place. There seems to be a gap in the research that seek to address how to allow people to create the social connections needed in a collaboration. This realization will also serve as a motivation for the work presented in this report; while previous research show interesting findings in relation to improving video meetings, the lack of focus on personal connections calls for further research.

All in all this points in a direction where it is reasonable to look in to how the bandwidth of video communication tools can be extended to include more information, and how social factors can be incorporated in to the existing setups and practices. The previous work shows, that designing technology for the video meeting or changing the existing setups indeed can have positive effects on the meetings.

Chapter 4

Design

So far, this report have established three main points; *(i)* Chapter 2 showed that the lack of connections between people have a consequence for distributed collaboration. These problems are especially interesting to consider in context of the video meeting given its role in distributed collaboration and as it - in media richness theory - is considered the next-best thing after face-to-face meetings. *(ii)* The process of creating socio-technical connections in the work sphere has been theoretically described by the notion of relation work. And *(iii)*, Chapter 3 described relevant related work concerning video meetings. The related work have provided valuable insights on how to transform traditional video conference setups to include additional information like non-verbal cues, but does not consider the fact that relational connections between people are needed to foster a good collaboration and communication. This research gap provides a strong motivation to investigate how to support relation work in video meetings.

These three insights motivates the problem statement of this report: *How do we design and build technologies that facilitate relation work?*. This chapter presents the design rationale, the design process and the design of *SideBar*, a videoconferencing system designed to support relation work.

SideBar is a videoconference meeting system with a special focus on supporting relation work. SideBar extends the traditional videoconference setup with tablet computers for all meeting participants. Through these tablets, participants are able to seek out information about each other and engage in backchannel conversations. The main feature of SideBar is an interactive mirrored video feed from the videoconference that allows users to tap the image of a person in the feed to bring up a profile for that person containing personal and professional information. Figure 4.1 shows the SideBar tablet application in use. The video feed from the conference is augmented with the names of remote meeting participants while the interactive areas are marked with yellow rectangles.

4.1 Design Rationale

In the paper “HCI, Natural Science and Design: A Framework for Triangulation Across Disciplines”[13], Mackay and Fayard argue that HCI researchers should triangulate over disciplines of science and design when embarking on HCI research projects. They present a framework for triangulating across different disciplines. The framework unifies theory, observations and design of artifacts and can be used to understand an HCI research approach. The design of SideBar follows the suggestions of Mackay and Fayard by theorizing the design of SideBar based on the observational studies of Bjørn and Christensen [1], iterating over the design in workshops with practitioners, implementing a working prototype, and finally evaluating the implementation in a feasibility study.

Figure 4.2 depicts the SideBar design process positioned in Mackay and Fayards triangulation framework. The design hypothesis as presented below is proposed based on the observational studies made by Bjørn and Christensen. The study has been included in Figure 4.2 although it is important to note that it is not a part of the work of this thesis. The design hypothesis was refined in design workshops using paper prototypes and finally realized in a working prototype. This prototype was evaluated in a feasibility study. Finally, the results from the study were used to derive a set of design guidelines. The rest of this chapter focusses on the design hypothesis, the design process, and the final design of the SideBar prototype.

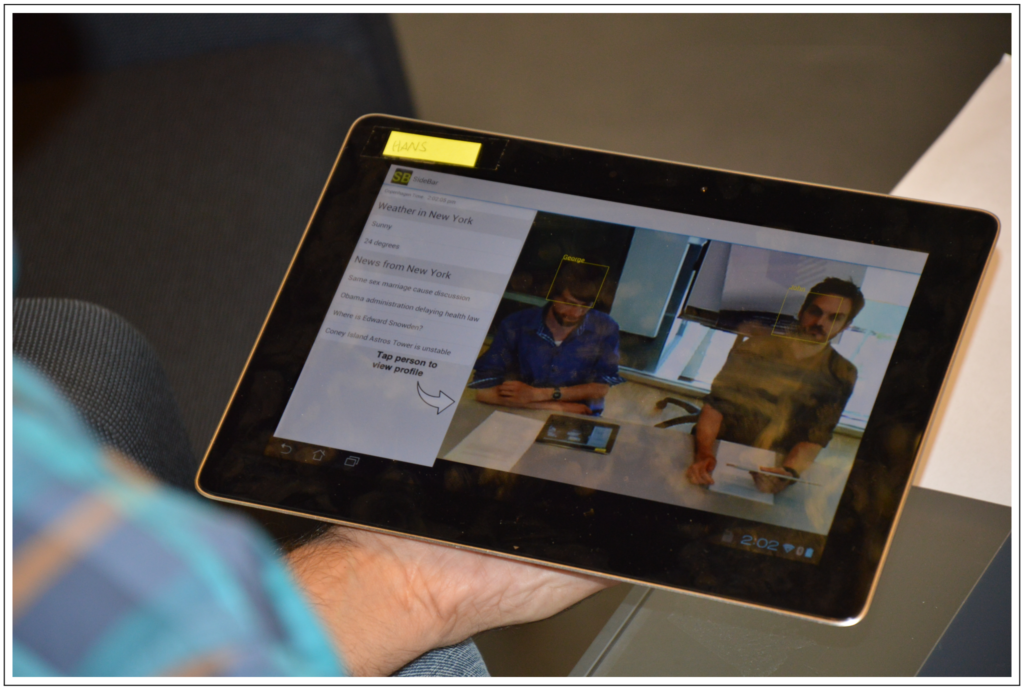


Figure 4.1: The SideBar app offers an interactive video feed.

4.2 Design Hypothesis

SideBar is designed to support relation work. It thus acknowledges that the dispersion of actors in a collaboration challenges the connections between people. The hypothesis behind SideBar is based on the notion of relation work and the examples of relation work as presented in [1] and described in Chapter 2. The hypothesis was used to draw out the general design for SideBar which was refined during design workshops and, in the end, validated in a feasibility study.

The basic hypothesis behind the design of SideBar is, that distributed actors should be made aware of each other both on a personal and professional level. This hypothesis is drawn from the argument by Bjørn and Christensen that the challenges of relation work in distributed collaboration is due to the lack of awareness between actors. Furthermore the hypothesis states that communication channels dedicated to give actors an opportunity to engage in relation work is needed. In detail the hypothesis states that:

1. Awareness - Relation work technologies should provide users with an awareness of each other. This awareness includes personal information such as name, age, hometown and interests and professional information such as education, position, and skills. The awareness information seeks

2. Opportunity for relation work - Relation work technologies should provide users with opportunities to connect to each other . While technology for communication already exists - email and chat for example are extensively used in collaboration - the opportunity of interaction should exist in conjunction with the awareness of each other. It is thus not sufficient to rely on these existing means of communication as they are detached from relational awareness.

This hypothesis was used to guide the design of SideBar as described below.

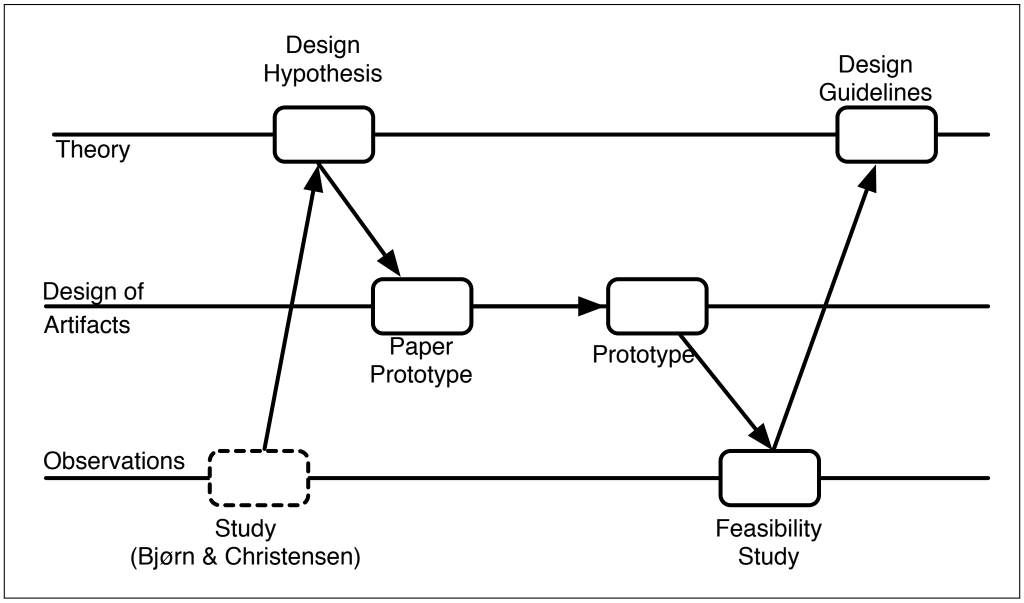


Figure 4.2: SideBar in the triangulation framework.

4.3 Design Process

SideBar was designed by researchers at ITU with input from a small Danish software company that engages in global software development. The company makes extensive use of video meetings with a branch of located in a different part of the world. The Danish office handles contact with customers while the offshore office handles implementation and test of software. The company has developed a model for collaboration that requires the teams to meet several times during a project. These meetings are done using video conferencing technology.

Based on the hypothesis of designing for relation work, SideBar is designed to give global actors a tool providing awareness about each other and the opportunity to talk to each other. The first part of the design involved writing scenarios and drafting paper mockups of the system. The second part of the design involved refining the mockups and presenting them at design workshops to develop the ideas.

The following is one of the scenarios initially written to explore the design of SideBar.

> *"Each thursday a video-meeting between a danish software company and its Philippine sister-company is held. [...] The video connection is initiated and everyone also launch their meeting app on their tablets. The manager in Manilla immediately notices that the point about changes to the module has been added to the agenda. Exploring a bit more, he finds out that the point was just added to the agenda which explains why he had not yet received an email about it. As the meetings are weekly, no introduction to the participants are given, rather the meeting manager in Denmark starts with the first point of the agenda. A few participants in Denmark however notice a person in Manilla they have not seen before. Indeed as they look at his information on their tablets, they find out that he has just been assigned to the project. Given recent re-arrangement of teams, he is now a the new responsible for testing in Manilla. The information also shows that he is not new to the company - in fact he's been employed for 3 years. [...] the meeting manager advances to the point on the agenda about the changes requested by the client. As he explains the proposed changes he has a few questions regarding the impact of the changes and how much effort is needed to implement them. Looking at his tablet he can see that the person who has worked the most on the module is indeed present at the meeting, and he can directly address questions about the changes to him [...]"*

This initial scenario focussed on a more general meeting support tool rather than a relation work tool. While relational aspects are mentioned – the system contains personal profiles that show e.g. for how long people have been employed – it is clear that the information sought and used in this scenario is of a very professional character. Furthermore, the scenario also focuses on the ability to share meeting agendas on the tablet – an interesting aspect although more an articulation work support than relation work. Also, the support of backchannel conversations is not mentioned. The scenario was thus changed - after all, one of the assumptions of collocated work is that relation work happens during informal smalltalk where all but professional work might be the conversation subject. The updated scenario focus more on providing both personal and professional information in SideBar as well as provide a back channel communication feature while leaving out the possibility for sharing meeting agendas. The main idea of the scenario though remains the same; SideBar should support video meetings where people do not know each other.

Based on the scenarios a series of paper prototypes were produced. These were simple hand drawn UI mockups and were used for further discussion and brainstorming. Finally, the mockups were refined by drafting wireframe mockups on a computer. These were then used in the design workshops.

We conducted two design workshops with the company in which the paper prototypes like the one shown in Figure 4.3 guided a discussion on how to design for relation work and on the design of the SideBar prototype.

Each workshop was attended by two researchers from ITU and two people from the company, lasted approximately 2 hours and was video taped. The purpose of the workshops were to get an industry input on the early design of SideBar.

Figure 4.3: A wireframe mockup of SideBar used in a design workshop. An interactive mirrored video stream is shown alongside information about weather and news stories at the remote site.

The design workshops gave us some important insights to improve the design of SideBar. Two general themes of comments were especially interesting.:

1. The paper prototypes used during the first workshop, focussed on giving people information about each other and how they might share relations. It was pointed out though, that another kind of information might be valuable to global actors; information about the setting and location of remote team members. The participants in the design workshop noted that the realization that the locations of remote colleagues are very similar (or quite different) might also be relevant to engage in relational activities and sidebar conversations. Furthermore,

the general knowledge about the location of remote colleagues might make people more comfortable contacting each other (i.e. general knowledge on the geographical location, time zone etc).

2. The participants at the design workshop noted that it might be beneficial to consider the team aspect of a collaboration. While the design of the paper prototypes focussed on one-to-one connections between people they argued that to fully support establishing connections between team members, the fact that *teams* are usually used in global collaboration should be considered as well. Indeed, relation work is about creating the connections to form a network. A part of this network can be seen as the connections between members of an organizational team that has been assembled to solve a given task. The feedback from the company thus fit well with the relational aspects of SideBar.

The final design of SideBar incorporates the two main findings from the workshops as described in the following.

4.4 SideBar

SideBar is a videoconferencing system with a special focus on supporting relation work during the meeting. Offering an interactive mirrored video feed from the video conference, SideBar enables meeting participants to seek information about each other and engage in back-channel communication.

The main feature of SideBar is an interactive mirrored video feed from the video conference which is shown on a tablet pc. The SideBar system tracks people in the video feed, allowing users to tap people in the video to bring up a personal profile for that person. The profile contains personal and work related information and access to a communication backchannel with that person

Before explaining the design of SideBar in detail, it is important to point out two important design choices that were made; *first*, SideBar is designed to facilitate relation work in video meetings. As mentioned in Section 2.1, the lack of awareness and shared physical spaces and artifacts requires distributed actors to engage in relation work in global collaborations. Clearly, relation work is required in many aspects of the collaboration and not just within the video meeting. As motivated in Chapter 2 SideBar has been designed for the video meeting as it constitutes a very important and frequently used method for communication in global collaboration and due to its high communication bandwidth. In the future though, SideBar might be extended to focus on relation work in other situations as well. *Second*, SideBar focusses on providing information helping people create people to people connections. As explained in Section 2.1, relation work also includes the work involved in creating people to artifact and artifact to artifact relations. The latter two are not explicitly supported in SideBar however, again, future work might include this.

4.4.1 SideBar App Design

SideBar consists of several systems that work together. The user interface of SideBar however is running on the tablet application SideBar App and thus was the focus of the design process. The design of the SideBar App is explained in the following.

4.4.2 Interactive Video Feed

The interactive video feed is the main navigation screen of SideBar. The screen mirrors the video conference video feed to the tablet but augments it with information about the participants. The infrastructure supporting SideBar tracks people in the video feed and streams information about who is sitting where along with the video to the tablets. This enables an augmented reality-like interaction in which users can tap the image of a remote participant in the video feed to bring up a personal profile. The live feed was chosen to bridge the gap between knowing who is present in a meeting and actually making the link between that person and the video. Even if a new person joins a meeting, the system should be able to allow meeting participants to quickly gain some information about that person. The interactive video feed also contains information about the the context of the physical location of the remote site. Figure 4.4 shows a screenshot of the interactive video feed of SideBar.

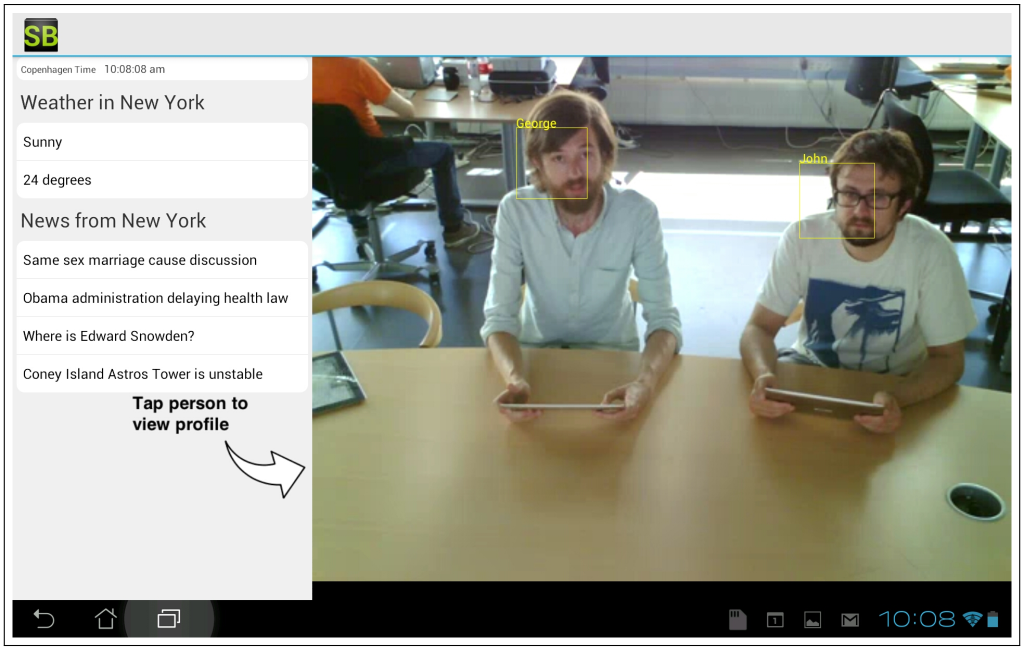


Figure 4.4: The interactive video feed of SideBar is augmented with the names of remote participants and squares marking the interactive areas.

4.4.3 Personal Profiles

Sidebar provides users with information about team members through personal profiles. Users are able to seek out information about each other – information that contains both personal and professional aspects. The information includes for example name, age, hometown, profession, education, and interests. This information can be used by the users to acknowledge similarities between each other and hopefully be the first step in creating connections between each other. Figure 4.5 shows a screenshot of a personal profile.

4.4.4 Backchannel conversations

With information about each other ready at hand, SideBar allows people to engage with each other in backchannel – or so called sidebar – conversations. One shortcoming of the common video conferencing equipment is that it provides no room, space or opportunity for sidebar conversations among the globally distributed actors. Such sidebar conversations about various significant and wholly insignificant topics are part of what makes up relation work in the local setting. One of the aims of Sidebar is to provide the globally distributed actors with "similar" opportunities for sidebar interaction and conversation that we know for local collocated interaction. The backchannel functionality supports this aspect. Figure 4.6 show a screenshot of the backchannel screen.

4.4.5 Location

SideBar includes a dedicated screen providing information about the location of remote people. An obstacle to creating personal relation across borders can be lack of knowledge about the location for remote participants. The location screen provides very basic information about the location of other as well as a map visualizing the location. Furthermore, information about weather and recent news from a location is available from the interactive video feed screen. Figure 4.7 shows the location screen.

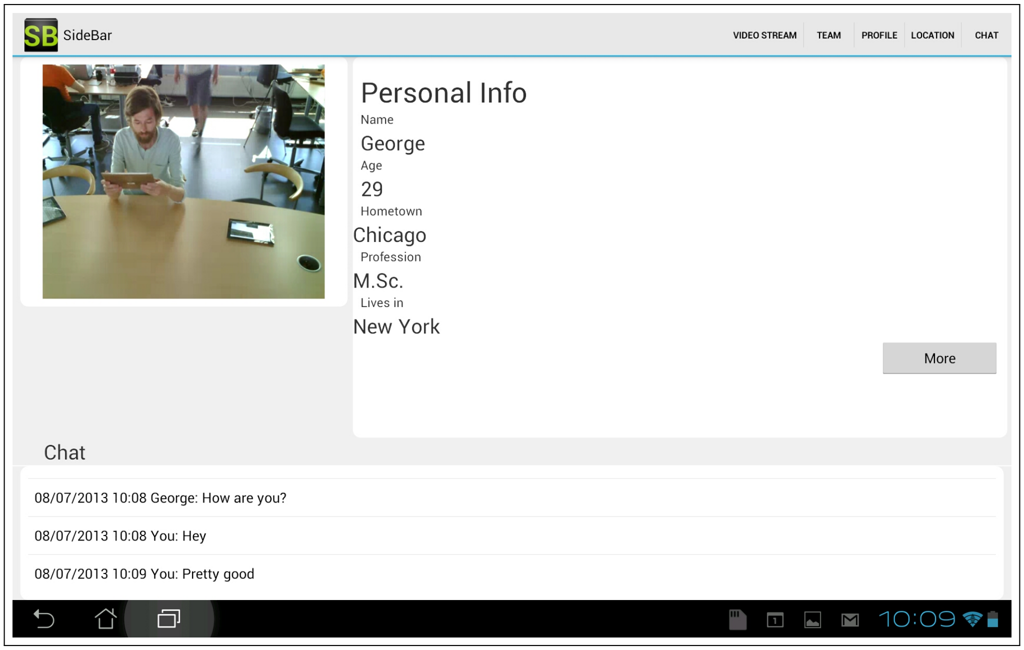


Figure 4.5: The profile contains information about the person, the live video feed, and access to chat, location, and team information.

4.4.6 Team

SideBar provides information about the meeting participants as a team as well. This, again was an input from the design workshops. The team screen is provides a side-by-side overview of the different people in the meeting. The information displayed a condensed view of the personal profiles, and the idea is to provide a quick overview of the people where it is possible at a glance to spot e.g. similarities or differences between people in the team. Figure 4.8 shows the team screen.

4.4.7 Login

The login screen is the entry point of SideBar. It contains drop boxes for users to select name, location and meeting before starting the meeting. Figure 4.9 shows the login screen.

In summary, SideBar is a tablet based application designed to support relation work in video meetings. Its main feature is an interactive mirrored video feed from the video conference that allows users to tap the image of remote participants to inspect their personal profiles. The profiles contain personal and work related information and the ability to chat with each other thus providing a backchannel - or sidebar - conversation feature. Furthermore, SideBar contains information about locations of remote team members and information about the team as a whole. The next chapter presents the implementation of SideBar.

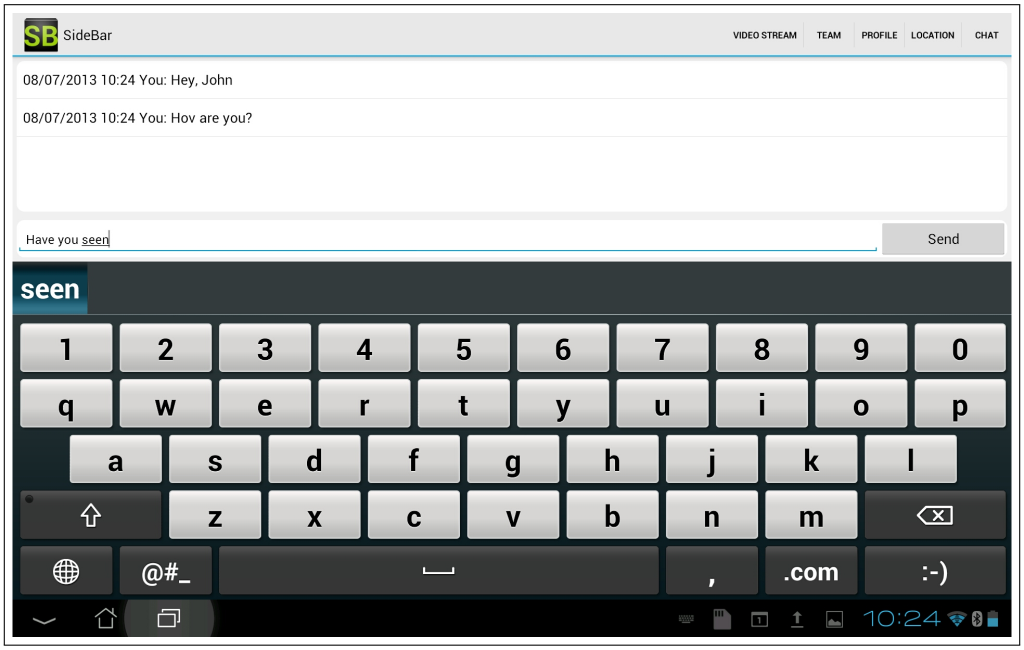


Figure 4.6: SideBar supports a communication backchannel though chat.

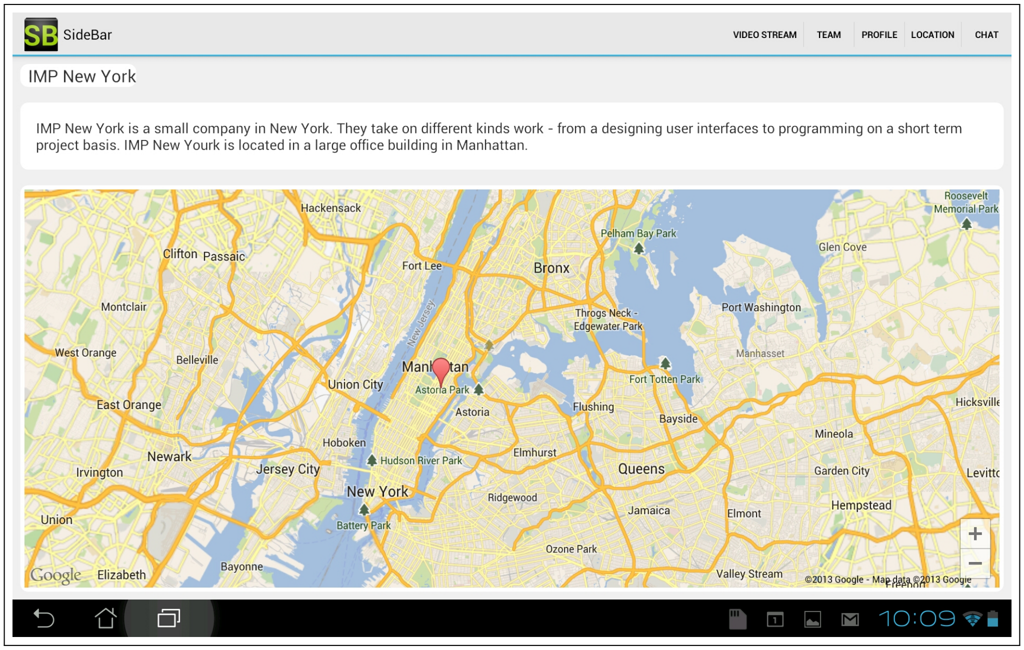
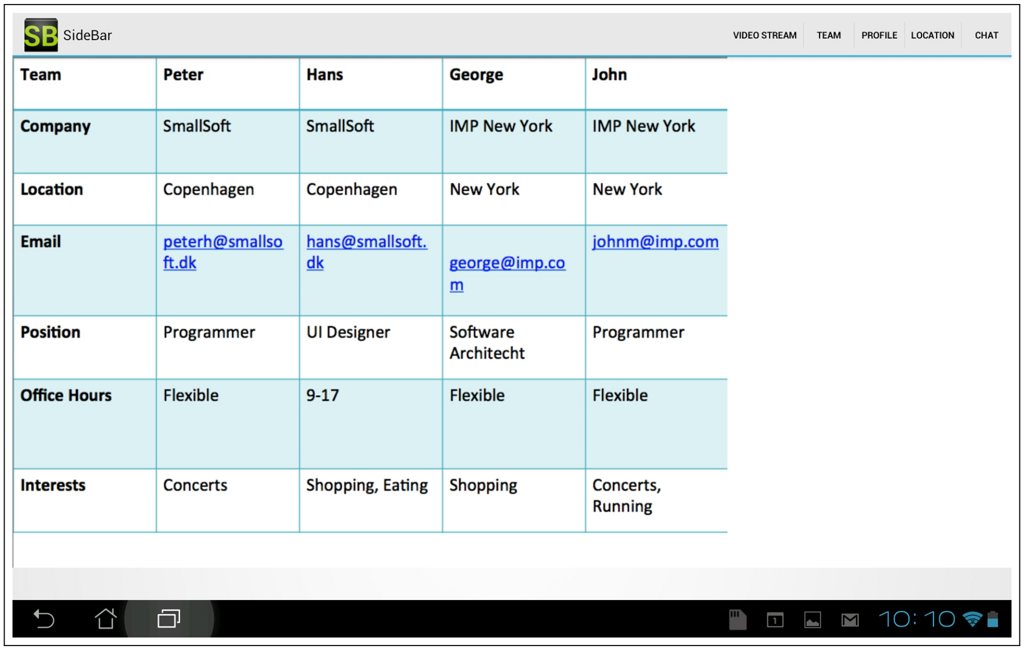


Figure 4.7: The location screen visualizes the location of remote participants on a map.



Team	Peter	Hans	George	John
Company	SmallSoft	SmallSoft	IMP New York	IMP New York
Location	Copenhagen	Copenhagen	New York	New York
Email	peterh@smallsoft.dk	hans@smallsoft.dk	george@imp.com	johnm@imp.com
Position	Programmer	UI Designer	Software Architecht	Programmer
Office Hours	Flexible	9-17	Flexible	Flexible
Interests	Concerts	Shopping, Eating	Shopping	Concerts, Running

Figure 4.8: The team screen provides a simple condensed view of the team members.

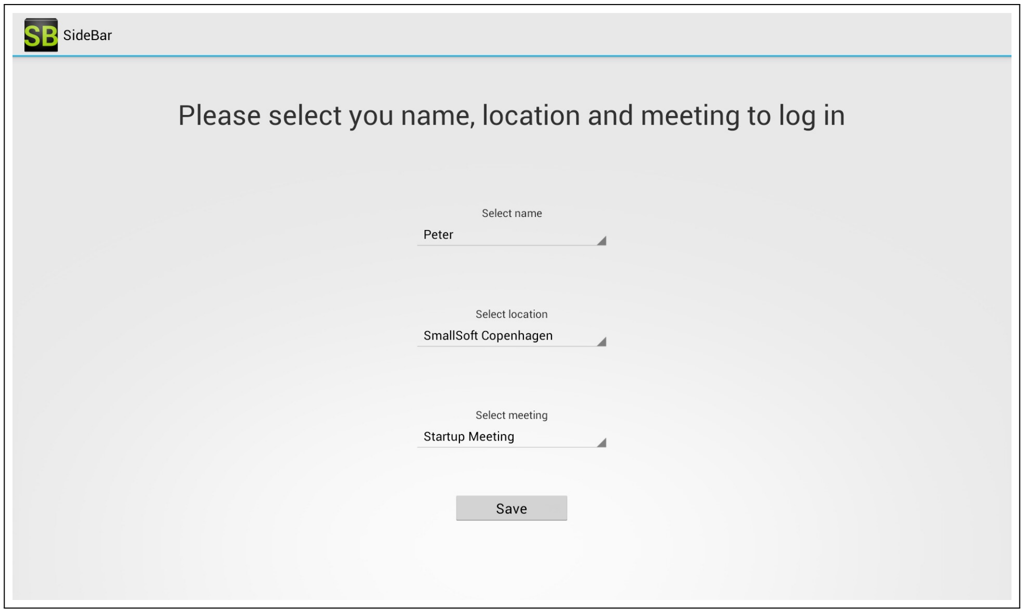


Figure 4.9: To log in, users must choose their name, location and the meeting they are participating in.

Chapter 5

Implementation

The SideBar system is composed of several systems that work together; **SideBar App** is the tablet application and user interface, **Relation Server** is the web server and database system handling data access to all relevant information, **Tracking Client** handles face recognition, **VLC** is used to stream video to the tablets, the **Registration App** allows for registration of new users, locations and meetings, and finally, any **video conference** setup can be used to handle the video and audio connection between sites. This chapter explains the implementation of these systems and how they work together.

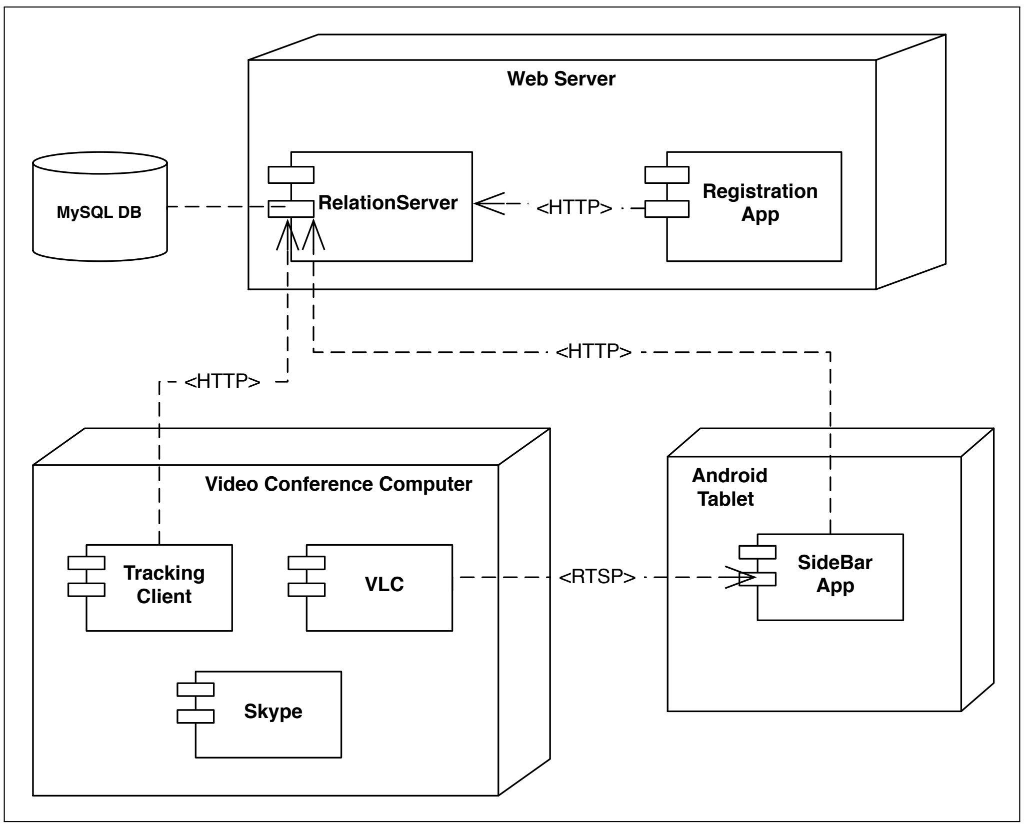


Figure 5.1: The overview of the SideBar system.

Figure 5.1 shows the component diagram of of the SideBar system architecture at one location. The Tracking Client performs face tracking on frames while VLC streams video. The video is sent over RTSP to any connected peer, while the tracking information is sent over HTTP to the Relation Server. The SideBar App running on tablets can access video by streaming it over RTSP from VLC while tracking data, chat, personal and location data is available from the Relation Server. The Registration App allow for new entries of users, locations and meetings. This information is posted to the Relation Server and saved in a MySQL database. Meanwhile Skype handles a high quality video and audio connection between sites.

5.1 SideBar App

SideBar App is the tablet application and user interface of the SideBar system. SideBar App is implemented in Android 4.0 and is designed to run on a 10.1 inch tablet. SideBar App handles the login procedure, streaming video, chat, and implements the profiles, location and team profiles.

5.1.1 Video Streaming

Video streaming is used in two aspects of SideBar; logging in and providing the video overview video steam. SideBar uses the standard Android video player - `VideoView` - for video streaming. This approach takes advantage of the fact that the built in video player handles connection, buffering, downloading, and decoding. A custom view, `PositionDrawableView`, handles drawing on top of the videos. This view is laid out on top of the video and will constantly draw rectangles around faces in frames to display interactive areas. On the overview video steam, the names of remote participants are also drawn over their faces to ease navigation. Only within these interactive squares is touch enabled - touching anywhere else on the video will not take the user to a profile or another screen. This is achieved by comparing position where a users taps to a list of positions of known people in the video feed. These position are constantly updated by polling new information from the Relation Server.

5.1.2 Services

Data exchange with the Relation Server is handled by three services; `ChatService`, `PositionService` and `ServerComm`. `ChatService` and `PositionService` are services that constantly pull the Relation Server for chat and position data. In case new data is available, they make an announcement through a broadcast. Any class or activity[1] can thus subscribe to these broadcasts to receive position or chat information. These services only run if an active Activity or service has requested it and is in need of the information they provide.

The `ServerComm` provides access to the Relation Server and wraps any HTTP calls needed to access or modify data on the Relation Server. These calls are needed to fetch information about people and locations when a user navigates to a profile or location screen. All calls to retrieve information about people, locations and meetings are handled by this service.

5.1.3 Login

A core feature of the SideBar system is that fact that users are tracked in a meeting. This feature is essential to make the interactive video feed allow navigation by tapping people in the video feed. The system knows where people are located in the video by means of image processing however it does not recognize who is where - simply that there are people present. The login procedure handles the creation of a logical association between a recognized face in the video and the personal profile for that person. This association is stored in the Relation Server as explained later. When logging in, users are first asked to select their name, their location and the meeting they are participating in. All this information should thus be entered in to the system using the Registrations App before a meeting takes place. After users have selected these options, a live stream of the local meeting is presented - e.g. the video stream from the camera in the room the user is sitting in. The user is then asked to select him or herself in the video stream. When selected, SideBar notifies the web server that a user has selected a position, and the logical association between the actual user and a tracked face in the stream has been made.

[1] An Activity in Android is a class that handles a UI

The login procedure is depicted in Figure 5.2; when the Relation Server receives a login it returns the url for the local video stream. The SideBar app hereafter streams the video while receiving position information. When the user selects a position, the logical association between user and position is made, and the Relation Server returns the url for the remote video stream.

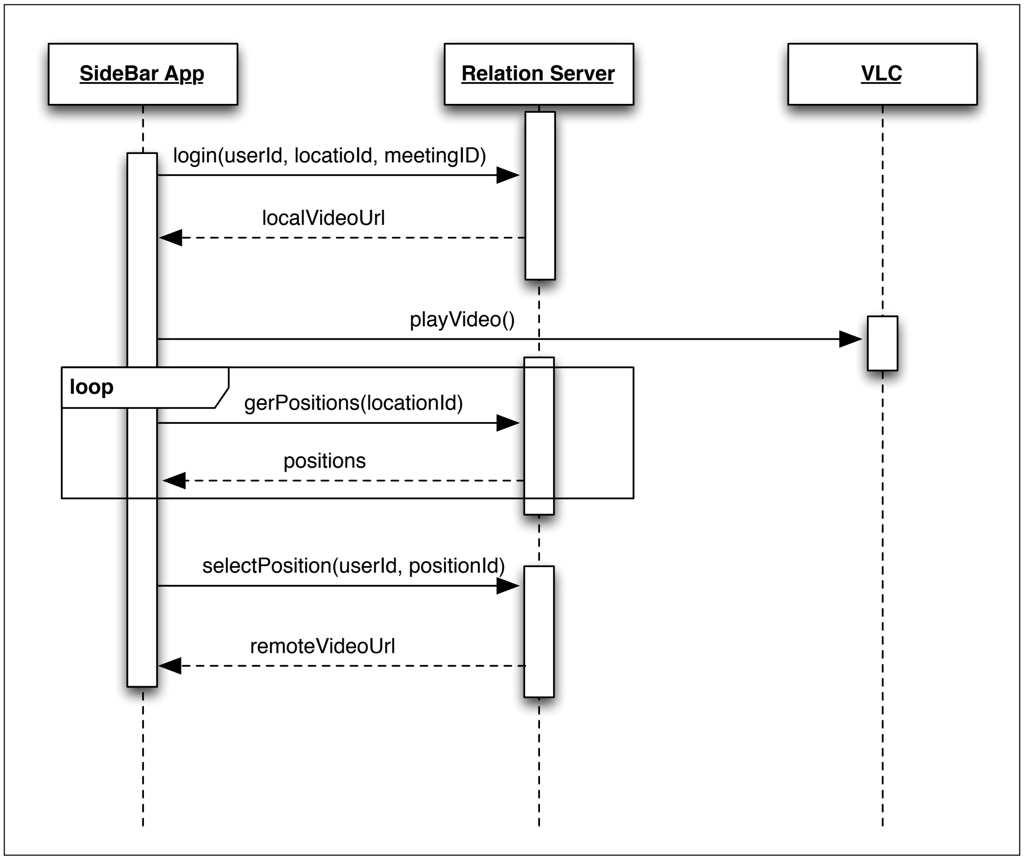


Figure 5.2: UML sequence diagram of the login procedure.

5.1.4 Tablets

SideBar App is designed as an Android application running on a tablet. The choice of the tablet as the computing device is a deliberate choice for several reasons; *(1)* the small and flat designs of tablets will cause less clutter on the meeting table compared to designing for e.g. laptops, *(2)* the high resolution and medium sized screens provide a possibility show good resolution images and more information, and *(3)* the tablets can be located in the meeting room to be picked up for a meeting, and such function as an extension of the existing meeting technologies. If the tablets are used as a video meeting extension tool rather than e.g. a personal tablet, they might also be less obtrusive to the meeting. Finally *(4)*, the use of mobile devices allows for for deployment on tablets with a mobile data connection. This feature could be especially valuable in case the wifi is unavailable as it would provide a communication channel that could be used while the wifi problems were being fixed.

5.2 Tracking Client

The SideBar system makes use of a live video feed and position tracking of people - the latter is handled by the Tracking Client. The application is implemented in Java and its main purpose is to connect to an attached camera and grab frames at a fixed frame rate. These frames are analyzed to track the positions of people. This information is then sent to the Relation Server.

The current implementation of SideBar grabs the first connected camera and uses it for position tracking. If the application is deployed on the same computer as the video conferencing software, the camera is the shared. If deployed on a secondary system, a dedicated camera should be connected to the Tracking Client computer. The latter kind of setup thus requires a camera to be placed alongside the existing conference camera. The placement of this new camera should be as close as possible to the conference camera to ensure the outputs of the two are similar. This approach was chosen to ease the setup of SideBar in any situation. Connecting to existing video conference technology to receive the conference video stream might be difficult depending on the setup and software used, so using separate cameras in case the same computer cannot be used, ensures that the SideBar system can be deployed most places without problems. It is also important to note that the ability for applications to share a camera depends on the operating system support for such. SideBar was implemented and tested on Macintosh computers running OS X where sharing cameras is possible. If deployed on a Windows system, a separate application that provides several handles to the same camera might be needed.

5.2.1 Analysis

Tracking Client makes use of JavaCV[2] to track the position of people in a frame. As position tracking can be CPU heavy, Tracking Client operates at a framerate of 5 FPS however this can be changed in a settings file. To track the position of people in a frame, the frame is converted to a grayscale image after which the `cvHaarDetectObjects` method of JavaCV can be used. This method takes a classifier that is used to detect the kind of object requested. Listing 5.1 shows the 2 lines of Java code it takes to get a list of positions of faces (`CvSeq face`) from a frame (`grabbedImage`).

```java
// Convert to greyscale image
cvCvtColor(grabbedImage, grayImage, CV_BGR2GRAY);
// Track faces in the gray image
CvSeq faces = cvHaarDetectObjects(grayImage, classifier, storage, 1.1, 3,
    CV_HAAR_DO_CANNY_PRUNING);
```

Listing 5.1: Converting a frame to greyscale and detecting faces.

The frontal face classifier bundled with the JavaCV distribution is used to detect faces in an image. The classifier describes typical features of a face and through the implementation have proven efficient at recognizing faces even in very zoomed out video streams. Each time a frame has been processed, the tracked positions of faces are compared to the previous tracking result. In case of overlap of 50% or more between tracked faces, the face is considered to be the same, and the position is updated. In case there exist no overlapping faces, the face is considered to be new. Figure 5.3 shows the class diagram of Tracking Client.

This approach limits the functionality of the system in terms of tracking people - ideally people should be able to move freely in a meeting and the system track regardlessly. However, since accurate tracking of people is a cumbersome task and that the main focus of this work is to support relation work in video meetings, this simplified approach is used. Once the positions of faces in the frame have been determined, the information is sent to the Relation Server.

5.3 VLC

Video is streamed to the SideBar App using the VLC[3]. VLC was chosen as it is a very versatile video application, supporting streaming of video using a variety of encoders and encapsulation options. Video is streamed over RTP using h264 encoding at a resolution of 480 x 360 and a bit rate of 500Kbps. In order for the Android video player to play the video the profile of the encoding is set to `baseline` [4]. To minimize delay as a result of video encoding, VLC

[2] JavaCV is a Java framework wrapping a range of computer vision libraries including OpenCV `https://code.google.com/p/javacv/`
[3] `http://www.videolan.org/vlc/`
[4] `http://developer.android.com/guide/appendix/media-formats.html`

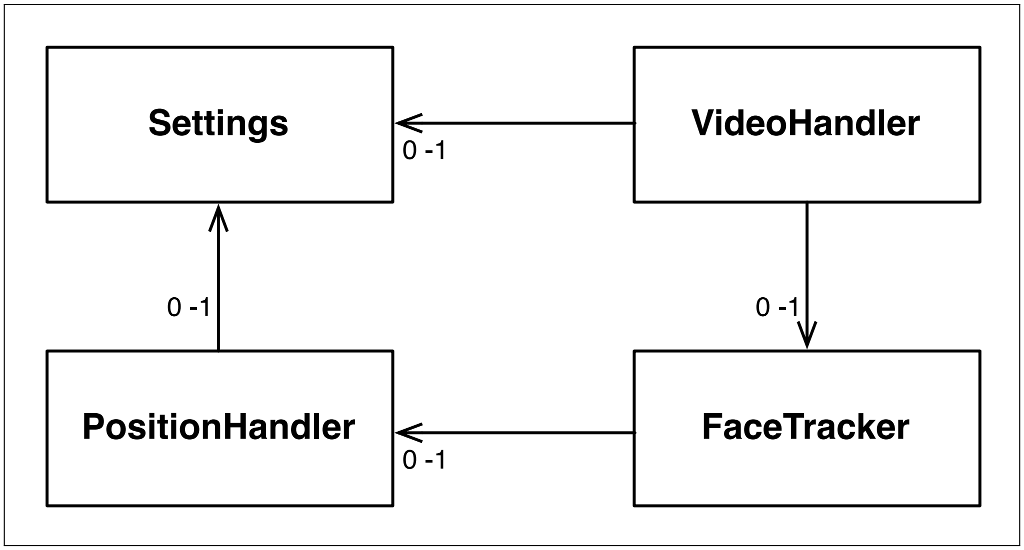


Figure 5.3: UML class diagram of the Tracking Client.

is instructed to use `ultrafast` encoding. This option, however decreases the quality of the video, so keyframes are inserted each second to ensure that the quality of the stream never drifts too far.

5.4 Relation Server

The Relation sever is the server backbone of the SideBar system. The main responsibility of the application is to store, handle and give access to all the data needed by the SideBar tablet application. The application exposes a RESTful like interface that can be used to access the data.

5.4.1 Data

The main feature of the Relation Server is to manage and give access to the data needed in the SideBar system. Relation Server is backed by a MySQL database that stores information about chat, meetings, locations, and people. Data access to the database is handled using Hibernate[5]. Relation Server also handles position data. This data though is not stored in the database but managed in-memory throughout a meeting.

5.4.2 Web Interface

The Relation Server is implemented in Java using the Java Spring framework[6] and runs in an Apache Tomcat server[7]. The Spring framework supports web development allowing for easy development of e.g. REST services and has support for Hibernate which is used to access and manage a MySQL database that stores all information for the system.

Relation Server exposes a RESTful like interface for communication with clients. All data-exchange between the server and applications is done using JSON[8]. The RESTful part of the server exposes a series of service controllers each mapped to a specific URL corresponding to the data type they handle. The controllers are mapped using the following url-scheme:

[5] `http://www.hibernate.org/`
[6] `http://www.springsource.org/`
[7] `http://tomcat.apache.org/`
[8] `http://www.json.org/`

`http://baseurl/RelationRestService/services/servicename/options`

Where the `servicename` is the name of the service requested and the `options` allows for specifying e.g. if a single or all instances of an object is requested. For example, issuing an HTTP Get to

`http://baseurl/RelationRestService/services/locationservice?locationserviceid=1`

will return the location with id of 1 as a JSON object while an HTTP Get to

`http://baseurl/RelationRestService/services/locationservice/all`

will return a JSON list of all locations in the database. Listing 5.2 shows the code that handles HTTP Get requests for a single location. The `@RequestMapping(method = RequestMethod.GET)` annotation maps the `getLocation` method to HTTP Get request for that service controller. When the application is deployed, the Spring framework handles calling the `getLocation` method when an HTTP Get request for `http://baseurl/RelationRestService/services/locationservice` is issued. The framework also handles automatic serialization of the retuned `location` object to JSON.

```java
@RequestMapping(method = RequestMethod.GET)
@ResponseBody
public Location getLocation(@RequestParam("locationid") int locationId) {
        Location location = locationService.getLocation(locationId);
        return location;
}
```

Listing 5.2: getLocation of the location service handles HTTP Get requests and returns a location.

The server exposes service controllers to access and modify chat, locations, meetings, persons and position data. These controllers support a subset of the CRUD[9] operations that are needed in the current state of the application.

5.4.3 Position

The Relation Server also creates and handles the logical associations between the tracked faces and the actual users. The Tracking Client simply tracks the position of faces in the pictures and send this information to the server. This information however, is not associated with any user (it is simply the location of *a* face in the frame). The logical part of the Relation Server keeps a list of all ongoing meetings, their participants and their positions in the frames. Upon login, a client will send the user id and the position id to the server. The server will assign the user id to the position so when other clients request position information, the position and the associated user id is sent together.

5.5 Video Conferencing

Any video conferencing setup can be used with SideBar as long as it supports one of the two following requirements; *(1)* it must expose a camera that VLC and Tracking Client has access to or *(2)* it must be possible to place a camera very close to the existing camera to provide a similar video stream to the SideBar app. For this implementation, Skype was used as the video conferencing medium. As both Skype, VLC and Tracking Client were running on the same computer, they all had access to the same camera.

5.6 Registration App

The Registration App is an HTML website for entering data in to the SideBar system. With the Registration App, users can register new users, location or meetings. The forms are implemented as simple HTML websites that posts data to the Relation Server on submit. Figure 5.4 shows the top the person registration form.

5.7 Setup

The setup of the SideBar system in a meeting between two locations requires the following software and hardware in each room.

1. 1 Android tablet with the SideBar App for each meeting participant
2. 1 web camera at each location
3. 1 computer with the Stream Client and VLC at each location
4. Apache web server running Relation Server and hosting the Signup Form

[9]Create, Read, Update, Delete which is implemented through HTTP Post, Get, Put and Delete

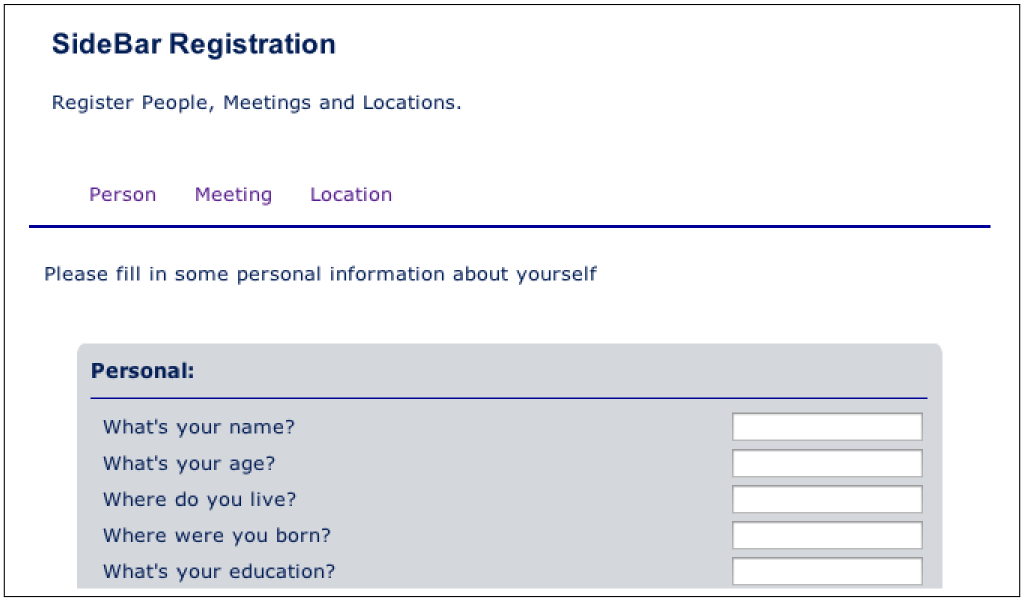


Figure 5.4: A snippet of the person signup form of the SideBar system.

To setup the system, a computer connected to a webcam running Tracking Client and VLC should be deployed at each site. In case a separate videoconferencing system is used, the webcam should be positioned as close as possible to the video conference camera to ensure a similar picture. The only configuration needed is to enter information about participants, locations, and meetings in to the system using the signup form. The signup form for location has a field to enter the IP address of the computer running VLC so the SideBar App can connect to the video stream.

In conclusion, the SideBar system consists of 6 systems that work together; SideBar App, the Android tablet application and UI, Tracking Client, the video processing service, Relation Server the web- and database server, VLC, the video streaming service, Registration App, the website for registrations, and any videoconferencing system.

Chapter 6

Evaluation

SideBar was designed to support relation work during video meetings. To validate the design and implementation of SideBar a feasibility study was conducted as presented in this chapter.

6.1 Objective and Limitations

The objective of the evaluation was two-fold; the first part was to investigate how useful SideBar is at supporting relation work. As described earlier, SideBar was designed to support relation work in video meetings. To validate the design of SideBar, the evaluation participants were asked to rate the usefulness of the features of SideBar. The second part, was to get feedback on some questions and concerns that had arisen during the design and implementation of SideBar. During the design of SideBar questions were raised as to the extent introducing a tablet computer in to the video meeting would disturb the meeting. This issue was also linked to the ease of use of SideBar – to minimize the time spent focussing on the tablet application, the system should be easy to use.

Figure 6.1: A snapshot of the evaluation. Users collaborate on a software task using SideBar.

6.1.1 Limitations

Relation work is a complicated concept and evaluating the extent to which a technology supports relation work is equally complicated. The feasibility study presented here thus has some limitations as explained below.

- Relation work is challenged in distributed collaboration however this evaluation was done at the same site. To compensate, the participants were asked to play out a scenario in which one side of the video meeting was located in Copenhagen, Denmark and the other in New York, USA.
- Relation work is needed to create and maintain connections needed in a collaboration. In this evaluation, some of the participants knew each other beforehand, so to compensate, participants were giving roles to act out in the evaluation scenarios.
- Relation work is an ongoing process. The connections needed in a collaboration are created and maintained over time. The evaluation presented here is based on a single meeting scenario that the participants were asked to evaluate. The temporal aspects is thus not considered.
- There is no doubt that a large number of participants is preferred to provide data for validating the usefulness of a system, or to empirically state its effects. However, in order to gain an initial verification of the design of the system, and to uncover usability problems, less participants can prove quite valuable. Virzi for example, argues that four participants is enough to uncover as much as 80% of a systems usability problems while seven is enough to uncover 90% [27].

6.2 Method

SideBar was evaluated with students and researchers at the IT University of Copenhagen. For the evaluation, the participants were grouped and asked to collaborate on a software task using SideBar. Each evaluation session consisted of two phases; a training phase in which participates were instructed in the usage of the SideBar App and a scenario phase where the participants collaborate on a software task. The scenario was a collaboration session between a Danish and an American software company. The scenario focussed on a small collaboration session between distributed developers meeting to discuss the implementation of an iPhone app. The focus on software development was chosen as most evaluation participants had experience in developing software. The evaluation scenario did not empathize the focus of creating personal connections. Rather it described a common software scenario - the initial discussion and division of work in a new project. This focus was chosen as the thought behind SideBar is to give meeting participants the opportunity to connect with each other using SideBar. SideBar is thus not tool that is required to complete a meeting - but a tool that can help in cases where its needed.

The following text was given to the participants at the "Copenhagen" site of the evaluation:

> *"SmallSoft is a Copenhagen based software company that specializes in app production. SmallSoft has been hired by a company to develop an iPhone application that allows people to book the company meeting rooms directly from their phone. To help out with the task, SmallSoft have contacted IMP New York – a freelance software company that offers help with software development. The teams from SmallSoft and IMP meet up for the first time in a SideBar meeting. The purpose of the meeting is to discuss the project including technologies and user interface and to split wok between the participants. Using the SideBar tablet application they seek out information about each other and are able to keep small chat conversations while the meeting is going on. After having discussed an overall plan for starting the project, they break up and decide to meet again a week after."*

Each participant was given a role to act out during the scenario. The reason behind this approach was that some of the evaluation participants knew each other before hand. The choice of given out roles thus prevented the participants in knowing to much about each other before the evaluation. Using roles on the other hand might also become an obstacle in the evaluation. Users might not be able to complete focus on the task at hand as they have to however in order to bring the scenario closer to a real life use case, and to encourage active usage of SideBar, these roles were used.

6.2.1 Evaluation Parameters

After a session, each participant was asked to evaluate the experience. The first objective of evaluation was to investigate the usefulness of SideBar, so participants were asked to rate the usefulness of the following features of SideBar on a 5-point Lickert scale:

1. Interactive video feed
2. Personal profiles
3. Location page
4. Backchannel communication
5. Team page

The second objective of the evaluation was to get answers and feedback on a number of questions that had arisen during the design and implementation of SideBar. Participants were thus asked to state the extent to which they agreed to the following two statements:

5. Distraction: The use of tablets distracts the video meeting
6. Ease of use: The system is ease to use

After the participants had answered these questions, a small semi structured interview was conducted where participants were asked about their experience with SideBar. These interviews included questions about the general experience with the system and also provided participants with the opportunity to elaborate on their previous answers and to give any comments on the system. These interview were taped for further analysis.

6.3 Participants

For the evaluation of SideBar, a total number of 7 participants were recruited on a volunteer basis (average age 32). The participant were grouped and placed in separate rooms to collaborate using SideBar. Table 6.1 shows the distribution of participants in the different sessions

Session	# Participants Room 1	# Participants Room 2
1	2	2
2	1	2

Table 6.1: Distribution of participants.

6.4 Setup

The setup of the evaluation included two rooms each equipped with SideBar; a video conferencing setup consisting of a 40 inch screen, a web camera, a computer, and a tablet for each participant. Skype was used as the video conference medium and the computers were running the SideBar system as described in Chapter 5. Figure 6.2 shows a picture of the test setup of one room.

Feature	*Min*	*Q1*	$\tilde{x}$	*Q3*	*Max*	*iqr*
Interactive video feed	4	4	4	5	5	1
Personal profiles	3	3.25	4	5	5	1.75
Location page	1	1.5	3	3	4	1.5
Chat	4	4	4	5	5	1
Team Page	1	1.5	4	4	5	2.5
Statement	*Min*	*Q1*	*Median*	*Q3*	*Max*	*iqr*
Distraction	1	1.25	4	4	4	2.25
Ease of use	3	4	4	4	5	0

Table 6.2: Lickert scale results from the evaluation questions.

6.5 Results

Table 6.2 shows the results of the of the questions as reported by the evaluation participants. The table shows the reported minimum value (*Min*), the first quartile (*Q1*), the median ($\tilde{x}$), the third quartile (*Q3*), the maximum value (*Max*), and the inter quartile range (*iqr*). These parameters are well suited for analyzing ordinal data, as the median presents the most frequent reported value and the *iqr* holds information about the spread of the data. On a Lickert scale for example, a high median and low interquartile range indicates a general satisfaction with little spread.

Interactive Video Feed The interactive video feed was one of the two SideBar feature that scored best on the Lickert scales ($\tilde{x}$*=4; iqr=1*). Participants generally liked the interactive video feed and it was found very useful for navigating. One participant even *"felt surprised how useful integrating information and video is"* and mentioned that the interactive video feed added more *depth* to the video meeting. During the observations of the evaluation, it was also clear that all participants were able to use the interactive video feed to navigate to each others profiles without problems. Participants quickly picked up on the roles of each other by using the video feed to make the connection between image and person.

Personal Profiles The personal profile pages were also well received by the participants ($\tilde{x}$*=4*) however with more disagreement (*iqr=1.75*)). During the scenarios, the participants used to profiles to explore each others profiles. The data they gathered from these profiles were used to direct questions at the right people. The profiles were also used to asses how to divide the work involved in creating the application mentioned in the scenario. In one session for example, a participant noted that *"You guys in Copenhagen are mostly UI designers [. . .]"* and argued for the division of work based on this information.

Location Page The location page was the feature that was rated lowest in the evaluation ($\tilde{x}$*=3; iqr=1.5*). When asked about the page after the evaluation, most participants noted that the information wasn't that useful for them. The information provided by the map however was used in one instance where a participant asked *"So your office is near Central Park?"* - referring to the position of the company being located near Central Park New York.

Backchannel The communication backchannel also scored the highest in the Lickert scale test ($\tilde{x}$*=4; iqr=1*). In particular, the participants noted that it provided them with an easy way of sharing textual messages and notes within the meeting. Several participants mentioned that with traditional video conferencing setups, one-to-one channel for chatting or sharing information are not easily accessible.

Team Information There was less agreement on the team information ($\tilde{x}$*=4; iqr=2.5*). This was also evident during the evaluation scenario where some participants used the page actively while others did not. In the former case, a participant found the information in the team page to be redundant as the same information was available on the profiles, while in the latter case, another participant found the team information useful while the teams briefly introduced themselves.

Distraction Participants disagreed on the question of how distracting the tablet application become in the video meeting ($\tilde{x}$*=4; iqr=2.25*). Some participants did not believe the tablets would disturb the meeting and other mentioned the already existing disturbances and argued that SideBar would not add more. As one participant said *"it [SideBar] does not disturb more than for example the printed out meeting agendas that are used sometimes."* while another noted that smartphones and computers already exist in the meeting rooms. Other participants, however had a different opinions. Two participant noted, that the eye contact that is shared when the camera and screen are not placed to far from each other, is taken away when people turn to the tablets. One participant said *"You think you have eye-contact as you see the same video on the tablet - but you don't"*. Lastly, a participant expressed the concern, that turning to the tablet felt like turning away from the meeting.

Ease of use Participant found the system to use ($\tilde{x}$*=4; iqr=0*), and throughout the evaluation scenarios were able to navigate within the system without many problems. One of the problems observed however, was the fact that the top-menu of the SideBar app is associated with a person and therefore not accessible from the interactive video feed. This caused some confusion as participants wondered where the menu was when they were intreating with the video feed screen. One participant however found that to much navigation was needed within the application.

In general the participants of the evaluation responded positively about the use of SideBar. Most notably, was the interactive video feed and the communication back channel that the participants found especially useful. With regards to the questions asked, the participants disagreed on the extent to which the introduction of tablets would disturb the meeting while in the general they found SideBar easy to use.

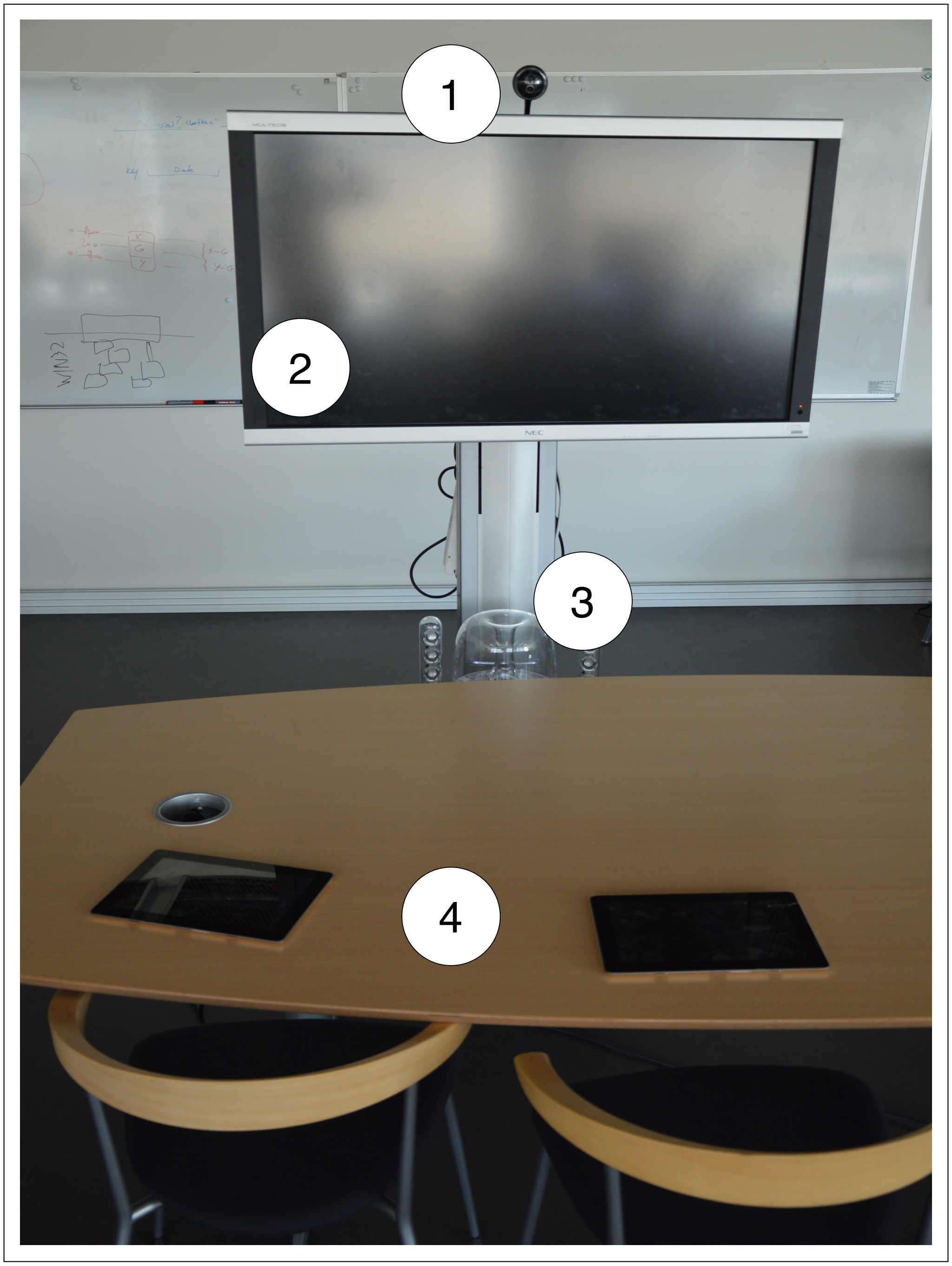


Figure 6.2: The evaluation setup consisted of *(1)* a web camera, *(2)* a large screen, *(3)* a set of speakers, and *(4)* the tablets running the SideBar app.

Chapter 7

Discussion

The evaluation presented in Chapter 6 investigated how useful the participants found SideBar and how they responded to a few questions raised regarding the design and usage of SideBar. The evaluation showed that the participants found SideBar useful for this matter and the participants commented on SideBar as being *"really helpful"* and *"the right way to go"*. In particular, the participants liked the linking of video and personal information through an interactive video feed. Furthermore, the communication backchannel was appreciated. The evaluation thus shows promising results for the support of relation work in video meetings.

The participants found the team and location information less useful compared to the video stream and communication backchannel. These two aspects of SideBar could both contained information in different place; the team contained some information that was also available in the profile pages, and the location information was split out between the interactive video feed (news and weather) and the location screen (description and map). The information about people and location could be possible be designed to only be available in one screen to ease navigation.

The participants found SideBar ease to use, and did not have many problems navigating the application, seeking out information about each other and about locations or using the communication backchannel. When asked about the possible distractions to a meeting however, the participants responded very differently. To really investigate how the introduction of a tablet based technology like the SideBar App changes the video meeting, a more thorough study should be made, possibly comparing meetings without SideBar to meeting with SideBar. For now, it is hard to say wether such a technology would introduce distractions that would disturb the video meetings.

The participants also provided some interesting comments in the system as a whole. One participant noted that *".. this [technology] could replace a kick off meeting"*. Indeed the kick off meeting in many companies is an important process in the relation work. While SideBar is not designed to replace this meeting, it is designed to facilitate this kind of – especially in situations where relation work is challenged by distance. The same participant noted that SideBar *"could be useful in many companies"*.

7.1 Personal versus Professional

While the general evaluation of SideBar was positive, and participants perceived SideBar as useful in the connection-making process, it became evident during the evaluation that participants mostly used SideBar to seek out information about professional experience. During the interviews, the same pattern emerged when the conversations revolved around the communication backchannel. Several participants mentioned the backchannel as useful for sharing information related to the meeting rather than the usage of chat as a way to connect to each other. The information such as profession and skills were also mentioned as being relevant, while information about interests and favorite music was less liked. This could perhaps be an effect of the scenario used in the evaluation. The scenario was designed as a distributed collaboration scenario that the participants, due to their experience with software development, could relate to. Furthermore, the scenario was designed to represent a meeting where participants that did not know each other met to discuss professional matters. The scenario however did not instruct the participants in actions in relation to building more personal connections.

7.2 SideBar Improvements

The evaluation of SideBar also pointed out some areas of improvements. One participant suggested that the information exposed by SideBar should be available even outside the video meeting. The current implementation of SideBar only makes the personal profiles available after login – a procedure that requires an ongoing meeting. The suggestion is interesting to consider as it would allow users of SideBar to seek out information about each other even outside the meeting. As previously stated, relation work is needed throughout a collaboration, and allowing an outside-meeting usage of the SideBar App might provide some support for this.

Two participants also mentioned the possibility of augmenting the video feed with more information than the current implementation offers. The SideBar App augments the video stream with names of the participants and rectangles marking the interactive areas, however providing more information directly on the video feed could perhaps be a useful feature.

7.3 Designing for Relation Work

As explained in chapter 2, relation work – i.e., establishing more personal and non-work relations – in collaborative situations is an important part of successful collaboration. This is even more so in distributed and global collaboration, which on the other hand also makes relation work more challenging. This is a core dilemma in relation work; relation work has optimal conditions in collocated collaboration but seems to be mostly needed in distributed and global setting. In the design of technologies for remote and distributed collaboration, support for conducting relation work should be considered. This section discusses ways of designing for relation work in distributed collaboration technologies.

As presented earlier, relation work unfolds in many aspects of collaborative work, and designing for relation work can thus be focussed on different technologies. While the work presented in this report focussed on supporting relation work in video meetings, technology support for relation work should be considered in other aspects of collaboration as well.

While the evaluation was conducted with a small amount of participants, and in a single scenario rather than an ongoing collaboration process, the work of designing and implementing SideBar, and the results of the evaluation suggest a number of design recommendations to consider when designing support for relation work.

Three main design dimensions are of particular importance in the support of relation work: *(i)* relational context awareness; *(ii)* relation building and sharing; and *(iii)* relationship maintenance. When designing for relation work, these three aspects should be considered. The core design approach is to design for a mutual awareness of relational context, which may trigger relational communication and sharing, which again builds and maintain relationships.

7.3.1 Relational Context Awareness

Maintaining an awareness of the nature of relationships between members of an organization is core to relation work. This happens while overhearing desktop discussions, ad-hoc queries, small exchanges during coffee breaks and in the hallway, and while setting up a meeting. Central to relational context awareness is that people build knowledge about each other and the relationships they are involved in. Design for relational context awareness is evident in architectural design of office space, which is designed with open office space where people easily can see and overhear each other, and the office layout is designed so that people easily "bump into" each other. Similarly, the use of shared artifacts like visible post-it notes, print-outs or drawing on a shared wall allows for the same kind of awareness that collocation brings. SideBar was designed to support relational context awareness by helping people render relevant relationships visible for others, and for people to be able to monitor the relationships of colleagues. The evaluation of SideBar showed that participant appreciated the awareness and the association between video and personal profiles.

7.3.2 Relation Building and Sharing

Core to relation work is the building and sharing of mutual relationships through different activities. A common way to build relationships is the classic team building exercises, company dinners or similar social activities. These activities share the similarity that they are explicitly designed to bring people together within a non-work context. One a more daily basis, informal talks around in a shared office space helps establish and maintain connections between people. SideBar provides users with a communication backchannel in video meetings. While several participants mentioned the backchannel as being useful for sharing information in the meeting, rather than using it for connection-making, this report argues for the need of dedicated relationship building and sharing methods. As one participant put it *".. this [technology] could replace a kick off meeting"* which fits well with the intention of designing for relationship building.

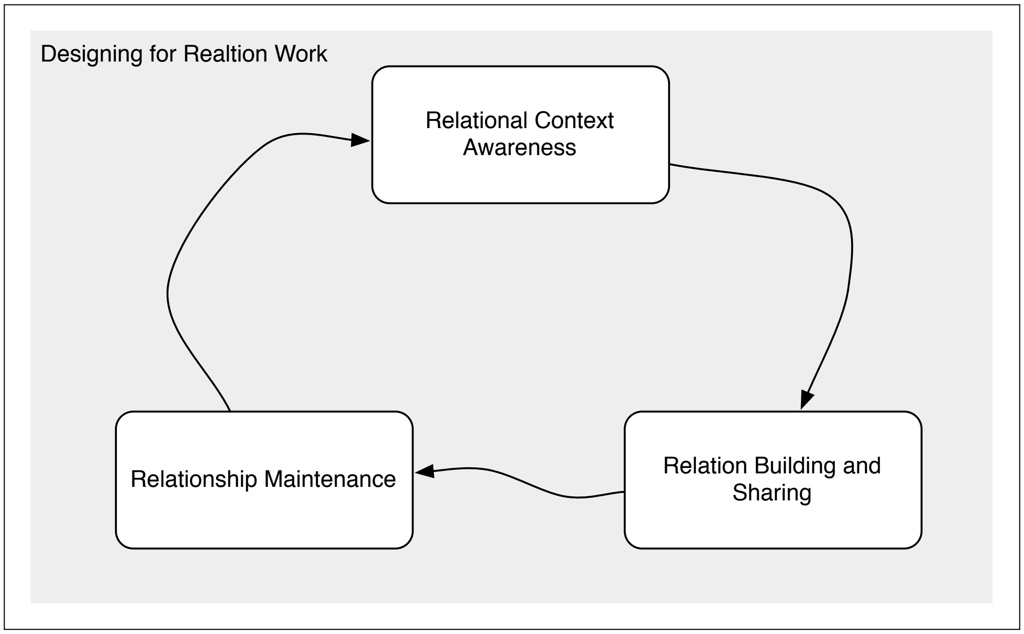


Figure 7.1: Designing support for relation work should consider three design aspect; relational context awareness, relation building and sharing, and relationship maintenance.

7.3.3 Relationship Maintenance

Once connections have been established, they need to be maintained and remembered. Often people keep specific artifacts such as pictures, tokens, prizes, diplomas, toys, and award medals from e.g. team building activities as souvenirs and reminders of specific relationships. However, more active involvement is often required to maintain relationships and keep them alive. Social media such as Facebook and Twitter, for example, encourages users to regularly update their online profiles with current information about their doings, interests, and whereabouts etc. The evaluation of SideBar only focussed on a single meeting and thus did not provide feedback on the temporal aspects of supporting relation work. However, given the nature of relation work, this report argues that relationship maintenance should be a part of the design guidelines.

Figure 7.1 summarizes the design recommendations. Technology support for relation work should provide relational context awareness, giving access to relationship building and sharing which in turn which again fosters relationship maintenance creating new awareness.

Returning to the research question raised in Chapter 1 - *How can technology support relation work in distributed video meetings?*, this report proposes three design aspects of relation work that are important to the design of new technologies; relational context awareness, relationship building and sharing, and relationship maintenance.

Chapter 8

Conclusion

Many problems are associated with distributed collaboration. This report focussed on the problem of lack of connections between distributed actors. The work of creating and maintaining the socio-technical connections between people and people, people and artifacts, and artifacts and artifacts have been theoretically coined as relation work and this report set out to answer the question *How can technology support relation work in distributed video meetings?*.

To address the issue of lack of support for relation work in video meetings, this report presented the design, implementation and evaluation of SideBar – a videoconferencing system designed to support relation work in video meetings. The design hypothesis of SideBar was to provide awareness and opportunities for relation work to video meeting participants. SideBar was designed in an iterative process where paper prototypes were used in design workshops with a small danish software company. The final design – as a product of the workshops – was realized in the SideBar system implementation.

The SideBar system is a videoconferencing system that augments the traditional setup with tablet computers for meeting participants. The main feature of the SideBar App running on these tablets is an interactive mirrored video feed from the videoconference that allows users to inspect profiles of each other by tapping interactive areas in the video feed. Furthermore, SideBar gives users a communication backchannel in the video meetings,

SideBar was evaluated in a feasibility study with students and researchers at the IT University of Copenhagen. The objective of the evaluation was to validate the design of SideBar and to answer some of the questions that had arisen during the design and implementation. Participants in the evaluation found SideBar useful and especially the interactive video feed and backchannel communication received were appreciated. The evaluation also showed pointed out areas of improvement;

Based on the design and implementation of SideBar and the subsequent evaluation, this report argues that three areas of design are of special interest when designing technology support for relation work; relational context awareness, relation building and sharing, and relationship maintenance.

8.1 Future Work

The results of this report also point in the direction of future work in the area of technologies supporting relation work. We suggest work continues in exploring the possibilities for designing for relation work and in general we see two directions of future work:

First, the evaluation of SideBar showed some promising results, however in order to assess any effects of SideBar a large evaluation should be made. During the feasibility study some issues came up that should be fixed before such an evaluation can take place. In particular, the evaluation participants found the location and team page less useful.

Second, this report focussed on investigating technologies for relation work in video meetings. As previously stated though, relation work unfolds itself in many other areas of collaborative work. Likewise, the connections created by relation work are needed in any collaborative work setting. This calls for an investigation in to the possibilities of supporting relation work throughout a collaboration and in many forms rather than only in the video meetings.

With some ways of future work laid out, we suggest researchers to head out and investigate further how technologies can support relation work.

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