Invited paper

Critical Issues using MBone-Videoconferencing on the Internet

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Desktop videoconferencing software tools are of paramount importance to collaborative cooperation in emerging virtual organizations and to teleworking in general. This paper discusses critical issues in communication and collaboration using desktop videoconferencing tools. We then suggest to videoconferencing software builders some actual software mechanisms that could implement these policies. Finally, we present some guidelines for conduct to people who will be involved in desktop videoconferences as participants.

Keywords: Videoconferencing, MBone, Internet, Multimedia, Telecooperation

1. Understanding Videoconferencing

Generally, we expect computer-mediated communication to change the relationship between the verbal and the non-verbal aspect of communication relative to a face-to-face situation. This relationship is very intricate in face-to-face conversation. Posture, gestures, distance, eye movements, intonation, all modify what is being said, and in fact overrule the meaning of the verbal part. "I hate you" can mean "I love you" depending on the nonverbal setting. When people communicate using computer mediated information technologies such as videoconferencing systems, the effectiveness and style of their communication is affected. In videoconferencing, there are fewer clues between the participants about who is who and about who can take the floor than in face-to-face meetings. This can be expected to lead to a number of changes in the participants' behavior. For instance, a participant wanting to impress authority on the others does not have the means of standing up, pacing to and fro, or gesturing menacingly in a meeting where only a head is seen and where the frame rate does not allow rapid movements. A participant who is eager to speak up but needs a superior to give him the floor cannot sit and fidget to signal this nonverbally. A participant wishing to give support or criticism cannot hum or gesture to indicate this. Perhaps headshaking can replace humming or gesturing in this last example. More generally, new ways have to be found to express actions in videoconferences.

In E-mail communication, no non-verbal aspect is present. This has been shown in the literature to potentially lead to misunderstanding and frustration (Markus 1994). Smileys, e.g. :-) are an attempt to overcome this limitation. The main thrust of an e-mail message, however, is left to the verbal content. This puts high demands on the author's and the reader's literacy. It can be expected that people who already know each other will be much better able to understand each other's e-mail messages than people who don't. For strangers wishing to communicate, for instance, the urgency of a request via e-mail, this can be very awkward. In our personal experience we have noted that adopting formal versus colloquial syntax can be used to indicate hostile versus conciliatory feelings. Incidentally, the lack of prominence of non-verbal communication in e-mail can sometimes be an advantage too: some people may not like each

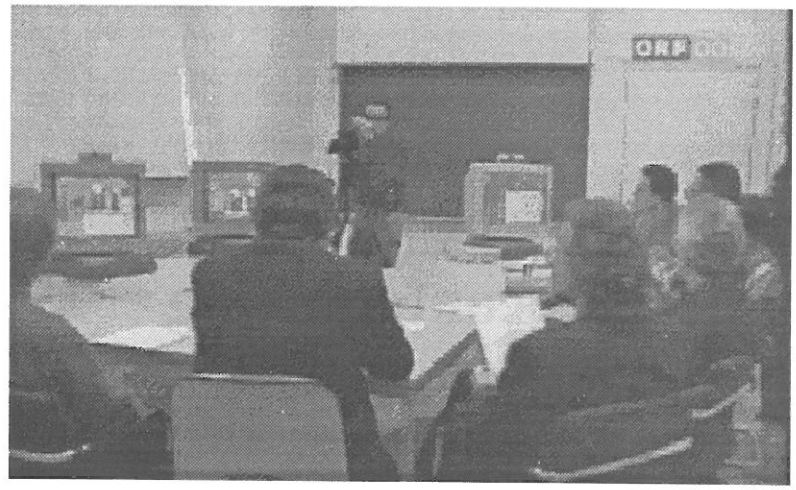

Fig. 1. Multipoint videoconference using desktop videoconferencing tools.

other's presence but they may be able to effectively handle necessary communication through e-mail. Also, people who do like each other may take more time doing things when in face-to-face conversation than when exchanging e-mail. They may "waste time" to their employers simply because they enjoy being together. So, to conclude, e-mail contact does not favour non-verbal communication. The nonverbal aspect of an e-mail message has to be either left out, or incorporated painstakinlgy into the verbal part.Videoconferences are in between face-to-face and e-mail contact. To begin with, this is true in a trivial sense. E-mail conversation is essentially one to one, and so is most of what is called videoconferencing today. The analogy to a real meeting would be a multipoint (many-person) videoconference as shown in Figure 3 and used on the Internet's MBone overlay network. Videoconferences are also in between face-to-face and e-mail, as far as the integration of verbal and non-verbal clues is included. Just like in the e-mail context, people will wish to find ways to deal with the non-verbal aspects of communication. For the participants, it is important not to get frustrated or spoil relationships. For those who pay for the videoconference, it is important to get value for their money, i.e. an effective meeting.

In this paper we focus on the use of distributed desktop videoconferencing systems. Desktop videoconferencing systems differ from room-based systems, and from desktop systems used in a room-based context — as shown in Figure 1 — in the way people communicate and collaborate, since the mediating technology is the workstation they use for daily work. In particular, we made studies using MBone — the Multicast Backbone — (Casner, 1993) videoconferencing tools on the Internet.

1.1. The History of Videoconferencing

Videoconferencing has its roots in the development of computer-based shared workspaces. The notion of group collaboration using computers was introduced by Bush (1945) using Memex, a group hypertext system. Engelbart (1968) implemented NLS/AUGMENT, one of the first systems using computers for synchronous and asynchronous group interaction. Johansen (1984, 1988) predicted the growth of interest in groupware technologies. Since then, there has been considerable development in collaborative systems. There is literature on tools for multi-user text-editing (Crowley et al., 1991; Ellis et al, 1991), annotation systems (Neuwirth et al., 1990; Cavalier et al., 1991), sketching tools (Minneman and Bly, 1991; Stefik et al., 1987; Ishii et al., 1993: Jacobson and McCanne, 1993) and group support systems (Nunamaker, 1991). Stefik et al. (1987), Mantei (1988) and Gibbs (1989) designed computer equipped meeting rooms for small group using the computers for problem solving in a face-to-face context. Larger electronic meeting rooms have been introduced by Nunamaker et al. (1991). Electronic meeting rooms can be used for inter- or intraorganizational meetings or classroom settings. The systems discussed so far were "room-based", i.e. the participants had to assemble in one place. Another line of

development was constituted by systems that allowed remote contact. Early electronic meeting systems lacked the ability of integrating multiple media types such as audio, video and textual information in one multimedia system.

The merging of workstation technology and real-time computer conferencing has had a significant impact on CSCW and group decision making and lead to the term "desktop conferencing". Research on early videoconferencing systems such as developed at AT&T Bell Laboratories (Ahuja et al., 1990), Bellcore (Root, 1988) or NEC (Watabe et al., 1990) had as their aim the provision of the facilities found at face-to-face meetings with remote groups. Recent developments on multimedia systems and networking technology show that using desktop videoconferencing for collaborative work on wide area networks such as the Internet is possible.

It is generally accepted that computer-supported decision making and communication results in many changes in communication patterns (Gaver et al., 1992; Heath and Luff, 1991), greater task orientation Niemiec (1984) and shorter meetings (Heath and Luff, 1991). Regarding the video component, Ishii, Kobayashi & Grudin (1992) point out the importance of gaze awareness, the ability to monitor the direction of someone's gaze and thus the focus of the attention. Similar results were found by Heath and Luff (1991) and Mantei et al. (1991). However, researchers have often discussed the lack of video of sufficient quality to support interpersonal communication (Egido, 1990).

1.2. Technical Introduction to Videoconferencing on the Internet

Our examination concentrates on the usage of packet switched networks, in particular the Internet. In a packet switched network, transmission lines are not reserved in advance, the data is sent in small portions, called datagrams, from the sender to the receiver or to a group of receivers. On the path from the sender to the receivers, the packets are forwarded by special machines, called routers. The packet switching approach is sometimes called connection-less or state-less delivery service, in contrast to the connection-oriented circuit switching method, where lines are reserved for the connections. The world-wide Internet is a large packet-switched network, but it is widely believed that real-time traffic requires a connection-oriented network service. Recent research (Clark et al., 1992) and experiences (Jacobson, 1994) has revealed that packet switching, compared to circuit switching techniques, is not less efficient in meeting real-time scheduling and delivery constraints. The weaknesses of packet- switched networks, namely the variation in the delay of each packet, usually called jitter, and packet loss due to occasionally packet dropping by routers can be diminished by buffering of incoming packets and the usage of loss-tolerant coding methods. The network jitter results in variation of packet interarrival times and out of sequence packet delivery. As a result, without taking into account jitter, the audio replay at the receiver will at least be hardly understandable. Network jitter is removed by the buffering the incoming data packets at the receiver and replaying the signal with some delay. The chosen coding method for audio and video data must be able to reconstruct the data with minimal distortion despite of packet loss. Due to the nature of video- and audioconferencing events, the need for distributing data to a group of participants, called multicasting, arises. Multicasting of packets differs from unicasting, where datagrams are delivered from one sender to one receiver, and from broadcasting, where datagrams travel from one sender to all receivers, in a way that datagrams are only delivered to members in a so called multicast group. Basically, we differenciate between point-to-point videoconferences — as illustrated in Figure 2 — and multipoint videoconferences — as illustrated in Figure 3. In point-to-point desktop videoconferences the need for floor control policies and mechanisms is very unlikely, but as the size of desktop videoconferences and the user participation grow, more issues of floor control become evident and important.

2. Social Activity Indicators

An important metric of social activity in a group meeting is the concept of "floor control". A meeting is a group setting in which only one participant can speak, or 'have the floor', at any point in time. So, informally, 'the floor'

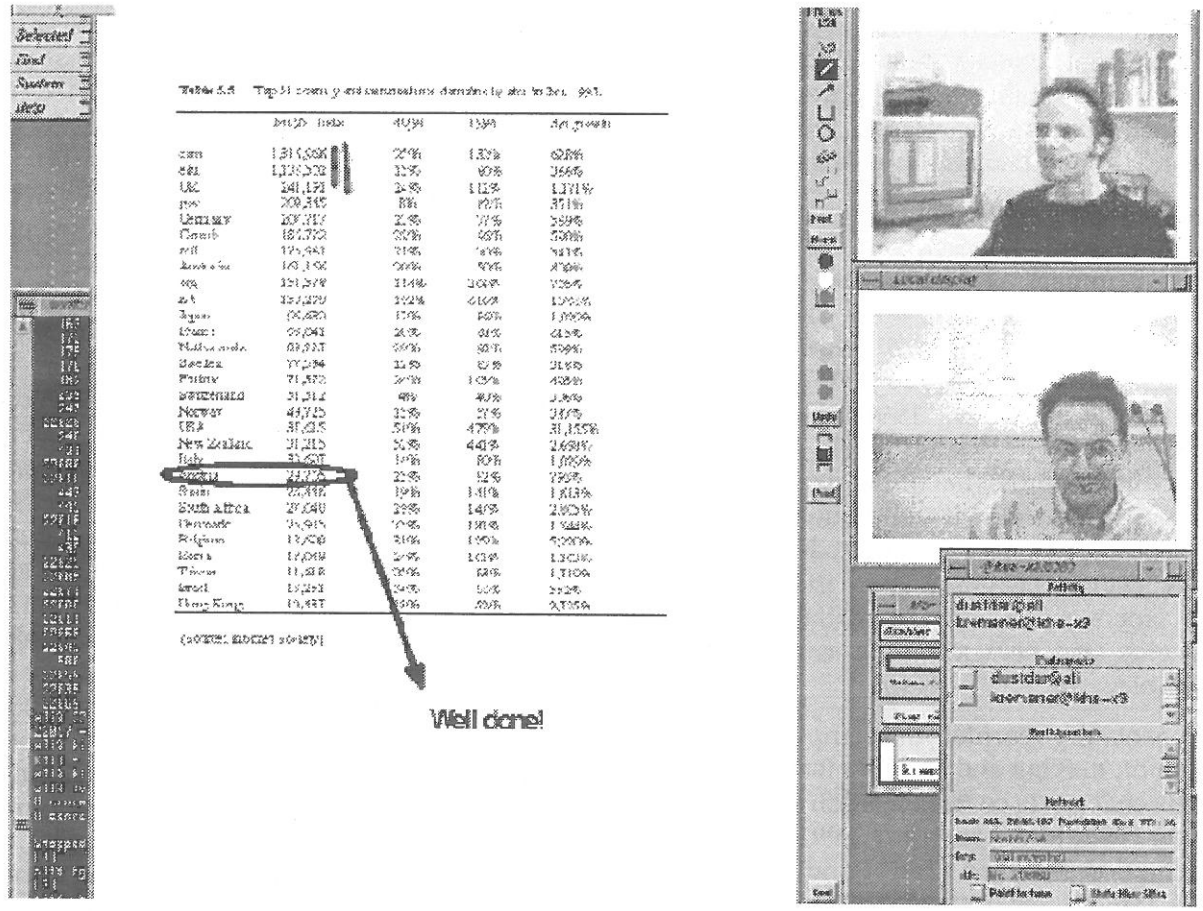

Fig. 2. Point-to-point desktop videoconference with shared whiteboard.

means 'the temporary monopoly for distributing signals to the other participants'. A more precise definition of the concept of 'floor' in videoconferencing can be found in Dommel and Garcia–Luna–Aceves (1997, p. 23): "Floors are temporary permissions granted dynamically to collaborating users in order to mitigate race conditions and guarantee mutually exclusive resource usage". This second definition shows that more than one 'floor' can exist at a moment of time in an electronic meeting. One person could have the audio floor, while another one has a whiteboard floor or a minutes floor. However, there will almost always be a main speaker at any point of time, and the loose definition, which captures that concept, will suffice for the present paper. How the floor is taken and lost, or granted, is crucial for a meeting's process and outcome. A meeting needs a *social protocol*, part of which is a floor control mechanism in order to proceed in a manner that is satisfactory to the participants.

For instance, a chairman may be appointed whose task it is to keep a first-in, first-out queue of people who have indicated a wish to speak by raising their hand. Alternatively, a participant with a high prestige may grant the word and the others will just wait until they are addressed by this high-status person. Or everybody may just try and get a word in, using their voice and body posture to indicate the urgency of their contribution. It is not hard to see how differences in culture can affect the floor control mechanism that is chosen. For example, participants from countries with low power distance will expect that anybody can take the floor whenever they want, unless other arrangements — such as appointing a floor-granting chairperson — have been made explicitly. The floor control mechanisms are engrained in national culture. Distributed collaborative systems such as videoconferencing systems must indicate something about the social world they represent. In particular questions such as who is on the system, what are the others currently doing and in which context they are. These social activity indicators (Ackerman and Starr, 1996) are becoming

Fig. 3. Multipoint videoconference on the Internet.

increasingly important the more people from various cultural and professional backgrounds have to collaborate. Furthermore, the lack of social activity indicators in collaborative systems, slows down the process of establishing a critical mass of users. Dealing with floor control issues two areas have to be discussed: floor control policies and floor control mechanisms. *Floor control policies* are employed within shared workspaces to control the form and type of access. Policies describe how conference participants request the floor and how the floor is assigned and released.

In context of desktop videoconferencing systems the simplest form of floor control would be if only one conference participant has the floor at any given time and the floor is handed off whenever requested by other participants. To obtain the floor the conference participant may either be requested to take an explicit action such as pushing one button in the user interface and being queued or to notify a conference moderator or chairperson. Floor control policies are being discussed in Altenhofen et al. (1993), Craighill et al. (1993), Crowley et al. (1990), Roseman and Greenberg (1992). *Floor control mechanisms* are low-level means used to implement floor control policies (Reinhard et al., 1994). A discussion of consistency mechanisms can be found in Ellis et al., 1991). Among the technical issues which need further investigation is research related to session control of video conferencing which manifests itself in floor control mechanisms. Loosely-controlled session as initiated by using the sd have little to less interaction among participants. In loosely-controlled sessions there is no mechanism to negotiate on parameters such as media type, media

encoding, encryption keys and membership issues. The Multiparty Multimedia Session Control (MMUSIC) charter provides an Internet-Draft, the Session Description Protocol (SDP) (Handley and Van Jacobson, 1995), towards the management and coordination of multiple sessions of multiple media used by multiple users. The functionality of such a protocol comprises:

- Session name and description.
- Start and end time for a session, start and end times if the session is active more than once.
- Type (audio, video, etc.), transport protocol (RTP, UDP, etc.) and encoding format of the media.
- Information to receive those media, i.e. multicast-address and encryption keys.
- Contact information for the person responsible for the session.
- Information about the bandwidth to be used by the conference.

3. Research on Using Videoconferencing Tools on the Internet

In the following section we summarize our findings gained from more than four years of videoconference usage on the Internet/MBone. We discuss some issues which are crucial in point-to-point and multipoint desktop videoconferences and give some suggestions for dealing with problems we encountered. The videoconferencing tools on the Internet/MBone can be classified as (a) video-tools, (b) audio-tools, and (c) shared whiteboards. These tools are not integrated, i.e. it is not possible to use an audio-tool to transmit video either from point-to-point or to multipoint. The same is true for video-tools and shared whiteboards. One of the first things one says after establishing a videoconference link is the question: "Can you hear me and/or can you see me?". This circumstance makes it impracticable to establish a videoconference without using a telephone as a *backup medium*. We shall first account a number of experiences in an informal way, ordered by type of communication medium. This is done in order to capture as much richnes as we can. Then we shall try to interpret these in the light of the five culture dimensions, and see whether we can find evidence that relates to our research framework.

Audio

In a point-to-point telephone conversation, the listener will frequently hum or say 'yes' to indicate he or she is listening and hears what is being said. In a multi-point telephone conference, this is not so easy. The listeners tend to be silent. This may leave the speaker wondering how what he said has been received. This is especially disturbing for 'political' persons, who rely much on atmosphere and eye contact to assess how their messages are received. The next thing one encounters is the problem of *concurrent speaking*. Generally speaking, network bandwidth is limited in most of the cases. Since audio- and video streams are sent over the Internet, the traffic is a problem. Therefore audio- and video data packets get lost. In case of audio packet loss one will feel very disturbed and the conversation will decrease in quality. It was mentioned above that collaborative systems lack "*social activity indicators*". Due to the fact that the videoconferencing tools are not integrated it is difficult for conference participants to check which of the participants is having, for example, audio- or whiteboard only. In Figure 4 one can see the active audio conference participants — represented by their email address — but in this window there is no link to the video tool.

However, the audio tool does show which conference participant is speaking. There is a "meter" below the loudspeaker symbol which moves according to the speakers' volume. Another useful feature is the "mute" button. There are cases in which a conference participant needs some "private" time or simply does not want to transmit audio from his or her site.

Given the audio quality that is reached with current technology, this will lead to packet loss. Videoconference participants from low power distance will have to get used to waiting for a silence before they talk. If the participants to a meeting are of similar power, there will not be any problems, as long as they know each others' relative status. Each participant will then know their place. But if they differ along the power distance axis, those low on power distance will tend to take the word uninvited, and to assume the others will do the same. This can lead to frustration. To tackle this issue, one could think of a feature such as a "*speaking time meter*" which shows to all conference participants the amount of time spoken to the group of participants. Currently, no such thing exists, but it

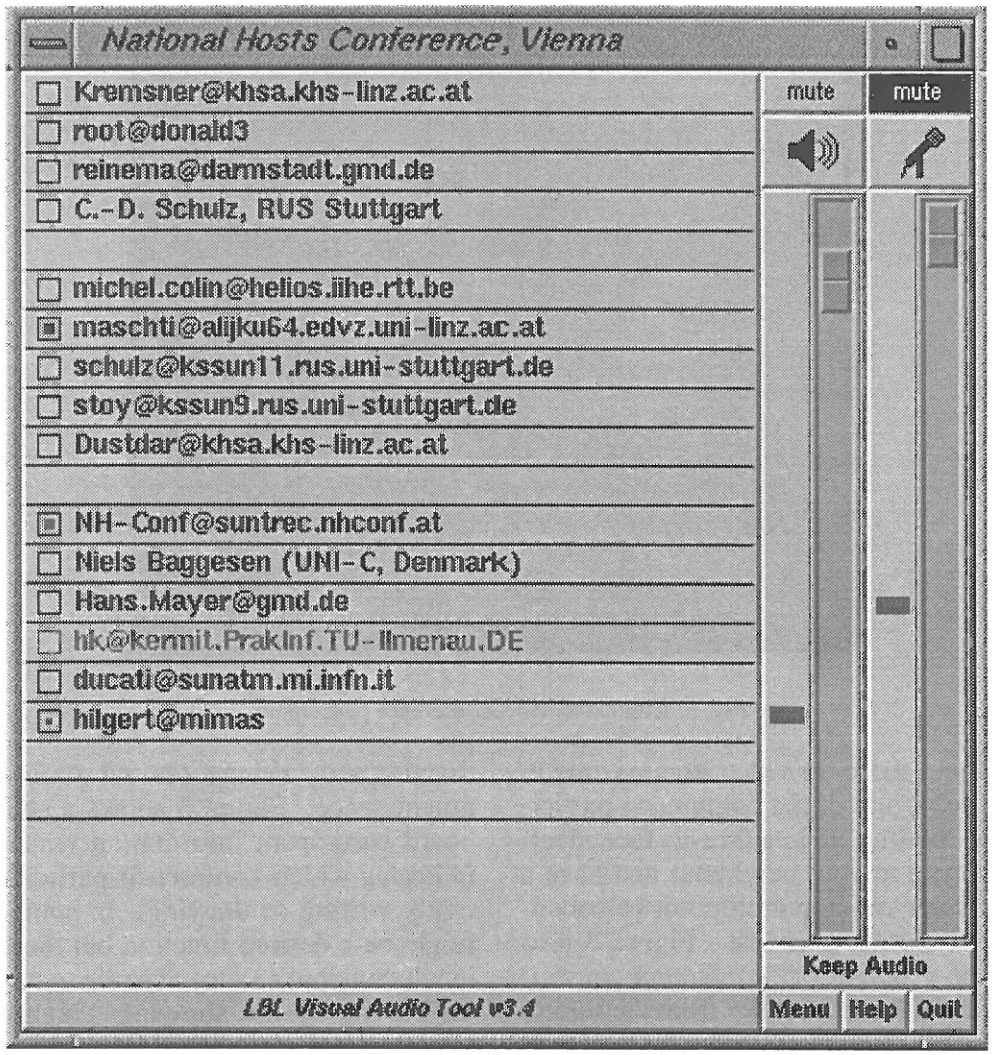

Fig. 4. Audio conferencing tool in a multipoint conference.

is technically easy to implement in a video- or audio-conference. A session chair could use such a device to ensure participation from all. In fact it is the sort of innovation that electronic media can bring.

Video

As stated above, network bandwidth is limited in most of the cases. Over the Internet, data packets get lost. In cases of video packet loss human perception is not so sensitive as it is the case with audio packet loss. If video packets get lost, the motion of the other videoconference participant(s) is "jerky". Nuances in facial expression will be lost and it will not be possible to infer how the others respond to what is being said. On the other hand, one can stare at a particular participant unnoticed, and still infer things from e.g. fidgeting. A problem which occurs in multipoint videoconferences as shown in Figure 4 is the missing link between audio- and video tools. In Figure 4 there are eleven active conference participants. One can hardly tell who is currently speaking, even when one enlarges the thumbnail video of the anticipated conference participant manually by clicking on it. Figure 3 illustrates very well one of the main problems desktop multipoint videoconference participants have to deal with, namely the question of how much "*real-estate*" the video for each conference participant gets on the users' computer monitor. As it can be seen in Figure 3, it is very difficult to have all video windows open, even if the user has a 21 inch monitor. One has to think of also having the necessary audio- and shared whiteboard windows open concurrently.

A feature which one can find in face-to-face meetings but which is missing here is the pos-

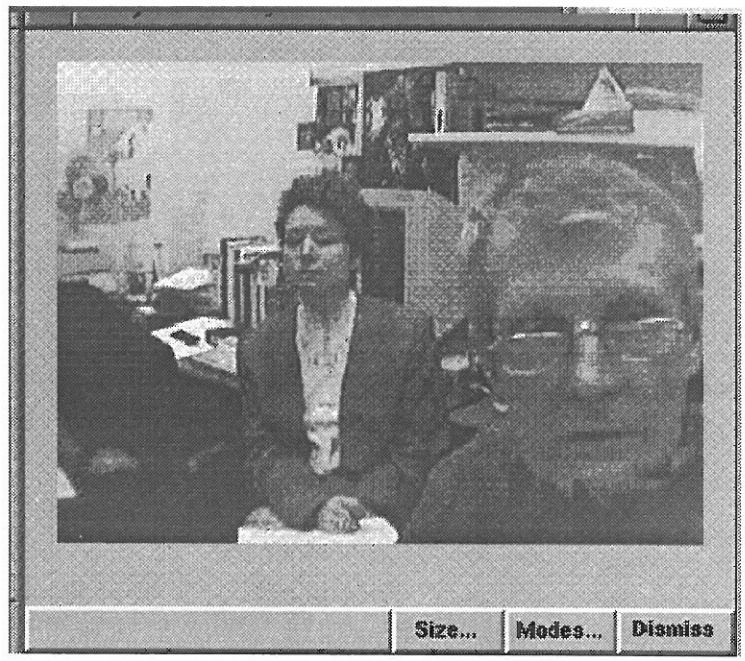

Fig. 5. Context of videoconference participant.

sibility to direct audio- or video streams only to one or to a subgroup of the conference participants ("side chatting"). In a face-to-face meeting you can turn to your neighbour and have a short chat. Using desktop multipoint videoconferencing this notion gets lost. Figure 3 also illustrates the problem of "*conference participants' context*". As one can see from the figure, the two large video windows differ a great deal. The window on top shows a large video image of a conference participant's head and a few clues of his office context. If you communicate with this participant you don't really know if he is alone in his office or if maybe two other people are sitting in a position where the camera cannot see them. Figure 5 illustrates the problem. The window below shows (at least) two conference participants sharing one videoconference workstation. Communication and collaboration using one workstation with two participants can be quite disturbing. In this area we suggest that desktop videoconferencing participants have at least two video cameras installed so that the conference partners have more clues on the organizational- and personal context.

Whiteboarding

Finally the shared whiteboard heavily depends on cultural issues. As it can be seen in Figure 2 the whiteboard application usually has some drawing and writing tools and some shared document space. Figure 6 shows a shared whiteboard participant information windows which indicates which conference participant is currently writing or drawing. In some cases this might be a desired function but there are cases in which it makes a lot of sense to "anonymize" the results by not showing which participant wrote on the whiteboard. If a contribution is anonymous, those who read it will tend to take it at face value. If it is not, it will be interpreted politically, on the basis of the reader's relationship to the author.

Another issue that sufaces in whiteboarding, or in simple e-mail, is use of language. For instance, whether a non-native English speaker has been taught British or American English makes a great deal of difference in the style they have lernt to adopt. Misunderstandings can arise because participants unknowingly offend the receiver. For example, U.S.A. inhabitants frequently do not bother to put any header (such as 'Dear X' or even 'Hi X!') above their e-mail messages. Receivers in many countries will not be favourably struck by what they perceive as a lack of respect, or manners.

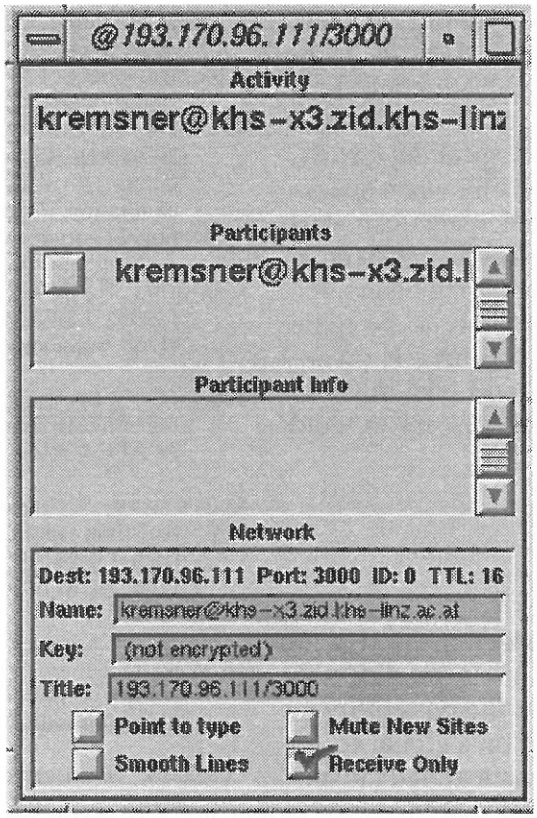

Fig. 6. Shared whiteboard participant information window.

4. Some Recommendations

Individualists will all freely express their opinions, with a focus on the task at hand. They may be of diametrically opposed opinions without having any personal antipathy. They may invest considerable energy into forming and negotiating *ad hoc* coalitions. In order to do so, they will occasionally engage in 'side-chatting' in small groups. As stated above, current videoconferencing tools on the MBone do not allow for this.

In an actual electronic meeting, actual groupware tools will be used. What floor control policies and mechanisms should these possess? Some recommendations can be summarized as follows:

- 'wish to interrupt' indicator for listener that floor holder can choose to acknowledge or disregard
- show people's responsibilities
- show people's privilege of floor-granting
- enhance video quality
- provide background information for videoconference participants
- allow side-chatting
- possibilities for non-verbal displays of strength are limited
- support for a formal protocol

In a global world, groupware should, if possible, accommodate all possible mixes of culture. Let us imagine a multi-cultural videoconference with participants from all synthetic cultures who do not know each other well. There are two chairpersons: one is the regular meeting chair, the other is a technical chair who knows about the software. The meeting could start with a little 'looking around' round in which all participants tell the others where they are and show the others, if their camera can be moved. This will allow the participants to do whatever their synthetic culture has taught them to do: be polite, come on strong, obtain information about the others' status or group membership.Then, the technical chair could explain how the meeting will proceed, and give examples of the features offered by the software. Prior consultation between the general chair and the technical chair would have set the guidelines here. Depending on the meeting's aim, the general chair can distribute the floor or 'I wish to interrupt' buttons could be used, anonymity of contributions can

be an option, speaking time could be regulated, side-chatting could be disabled. Also, the technical chair could give some advice about how to enhance communication, such as getting a proper lighting for one's face, speaking clearly, not moving about too vehemently when speaking. Thus prepared, the participants can start the meeting. It will be rather more orchestrated than a face-to-face meeting. Among others, the time slot for the meeting is likely to be quite strict, so that the meeting's end-time is predetermined. The general chair will take this into account, and do whatever is necessary to wind up the meeting in time.

5. Conclusion

Together with an Internet connection the MBone desktop videoconferencing tools provide the user and an organization with the possibility to communicate and collaborate on a global scale. However, the tools need to be integrated into organizational information systems such as workflow and groupware systems, word processing, project management software and spreadsheet applications and most important, they need to support "social protocols" and be culturally aware. Desktop videoconferencing is not a substitute for face-to-face meetings, but it forces people to change decision making processes, collaboration — and communication patterns. It is of paramount importance for computer scientist studying the field of videoconferencing on the Internet to look also at the organizational and cultural implications of the technology.

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DR. SCHAHRAM DUSTDAR is the head of the Center for Informatics at the University of Art at Linz in Austria, head of the Austrian MICE/MERCI-NSC research project (Multimedia Integrated Conferencing for European Researchers). His main fields of research are organisational implications of information systems and advanced information technology. His current research interests are multimedia information systems and organisational change where he co-authored a book entitled Multimedia Information Systems and co-edited a book on telecooperation in organizations. He is on the editorial board of the Journal of Multimedia tools and applications (Kluwer). He was a visiting research fellow at the Department of Information Systems of the London School of Economics during the academic year 1993/94 and in spring 1998 a visiting research scientist at NTT Multimedia Communications Laboratories, Palo Alto. He is co-founder and president of Caramba Labs., a software company developing Java based groupware and workflow systems.