Support for Group Awareness in Real-time Desktop Conferences

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ABSTRACT
Real-time desktop conferencing systems are multi-user computer applications that allow physically distant people to work together in a shared virtual space at the same time. These systems do not yet provide the rich communication and awareness that are possible in a face-to-face interaction. One of the elements lacking in desktop conferencing is *group awareness* - the up-to-the-minute knowledge of other people's activities that is required for an individual to coordinate and complete their part of a group task. This paper describes our initial investigations into computer support for group awareness. We present a framework for thinking about the concept that divides awareness into physical, task, and social environments, and then uses a proximity space to categorise group situations in terms of group awareness. From the framework, we have designed and built several *awareness widgets* for use in a groupware toolkit. These widgets assist conference participants in staying aware of others' locations when their views are separated, of others' task activities in shared and separate view situations, and of their past activities in semi-synchronous situations.

1. Introduction

Researchers in Groupware and Computer-Supported Cooperative Work (CSCW) investigate how technology can support effectively the interactions between people. One area of interest is *desktop conferencing,* systems that let people who are physically distant work together at the same time through their computers. These systems typically provide a shared virtual workspace where conference participants can see and manipulate work artefacts, and may also provide audio or video links.

Desktop conferencing does not yet allow the richness of face-to-face meetings. Audio and video links are poor substitutes for transmitting the physical presence of others (e.g. Egido 1988). Groupware applications such as multi-user whiteboards and editors are still rudimentary compared to their single-user counterparts. Compounding the problem, traditional social practices that have evolved in a face-to-face setting can be hard to enact through desktop conferencing, because the virtual tools and limited communication channels do not give participants all the subtle cues they need to manage the interaction.

We believe that one of the elements necessary for effective desktop conferencing is *group awareness.* Group awareness is the up-to-the-minute knowledge of other people's activities that is required for an individual to coordinate and complete their part of a group task. Group awareness is maintained by keeping track of

information such as other participants' locations in the shared space (where are they working?), their actions (what are they doing?), the interaction history (what have they already done?), and their intentions (what are they going to do next?).

In traditional face to face interaction, group awareness is required for coordinating activity, managing shared resources, and understanding the overall state of the activity. Since the intent of groupware is to provide for real and effective group work, which includes supporting social practices, it follows that group awareness will be important in groupware settings as well.

This paper describes some of our investigations in supporting group awareness in groupware. Section 2 presents a preliminary framework for organising and classifying group situations in terms of their requirements for group awareness. Section 3 introduces a few software components ("widgets") that we have designed to meet some of the needs identified in the framework. Section 4 describes related work and outlines our plans for further research.

2. A Framework of Group Awareness

We are constructing a framework for thinking about group situations in terms of the concept of group awareness. The need for this framework arose from our realisation that research into group awareness is widely distributed across several different research areas, and is not yet integrated into a coherent body of knowledge. Experimental results and principles can be found in psychological studies of attention (e.g. James 1950; Wickens 1984) and of situation awareness (e.g. Tenney et al. 1992), in ethnographic investigations into work situations (e.g. Heath and Luff 1991; Filippi and Theureau 1993; Suchman 1991), in the insights of groupware practitioners (e.g. Ellis, Gibbs, and Rein 1991; Stefik, Bobrow, Foster, et al. 1987; Tang 1989) and in investigations of distributed cognition (e.g. Norman 1993; Hutchins 1990). Our efforts are a start at organising knowledge about group awareness into a form that can drive the design of software components for groupware.

Categorising the Elements of Group Awareness

Our framework starts by dividing face-to-face group interaction into three environments: physical, task, and social.

In the physical environment of a face-to-face group situation, people acquire basic information about the presence, identity, and location of other participants by asking these questions:

- Who is present?
- Who are they?
- Where are they?

While these questions are easily answered in a physical meeting room, a desktop conferencing system can make the process onerous. The system may not even indicate who is present, or may show only cryptic identities such as machine login names. It may inhibit the casual interaction that usually precedes meetings and

that gives people a chance to find out about the other participants. It may not show where others are in the shared workspace. In addition to increased difficulty in answering these questions, the shift to a virtual workspace may alter some of the questions and their importance. For example, in the groupware setting, someone's actual physical location (such as "Vancouver") may be less relevant, but their location in the workspace (such as "viewing page one") becomes more important. The basic requirement for some type of location awareness still exists.

The task environment encompasses the work or activity that is the focus of the group interaction, and requires different kinds of group awareness. To manage shared tasks, people need to know what others are doing with respect to the group activity:

- What type of activities are others engaged in?
- What are their specific actions?
- What are people's task-specific intentions?
- How do others' actions constrain, free, or otherwise affect my actions?
- What changes have others made to the task artefacts?

In a face to face meeting, much of this information is acquired by seeing and hearing what people are doing with the task artefacts, even when we may be paying only peripheral attention to them. In groupware, this information is simply not available unless it is explicitly added to the communication channels provided by the application itself.

Awareness of the social environment is also a part of a face-to-face situation. People work together within a complex set of social conventions, many of which require them to remain aware of the others in the group. In a group activity, people use social awareness to determine:

- Can I disturb you?
- Are the others paying attention?
- What stereotype do you fit?
- Whom can I ask for assistance?

As with the other awareness types, the subtle cues necessary to determine these answers may not be transmitted by the groupware system.

Different kinds of group situations and tasks require these elements in varying degrees. The next section organises collaborative work into a proximity space that relates a variety of group situations to the elements of awareness mentioned above.

A Proximity Space for Group Awareness

Awareness in face-to-face situations has traditionally been tied to the distance between people, since we gather awareness information primarily through senses that are affected by distance. Proximity can be used as a basis for two dimensions in the space of group situations - view and task. View separation is the distance between what group members can see closely enough to work with; task separation is how closely people are working together on the same task. In groupware systems, applications that tie everyone's view together, called "what

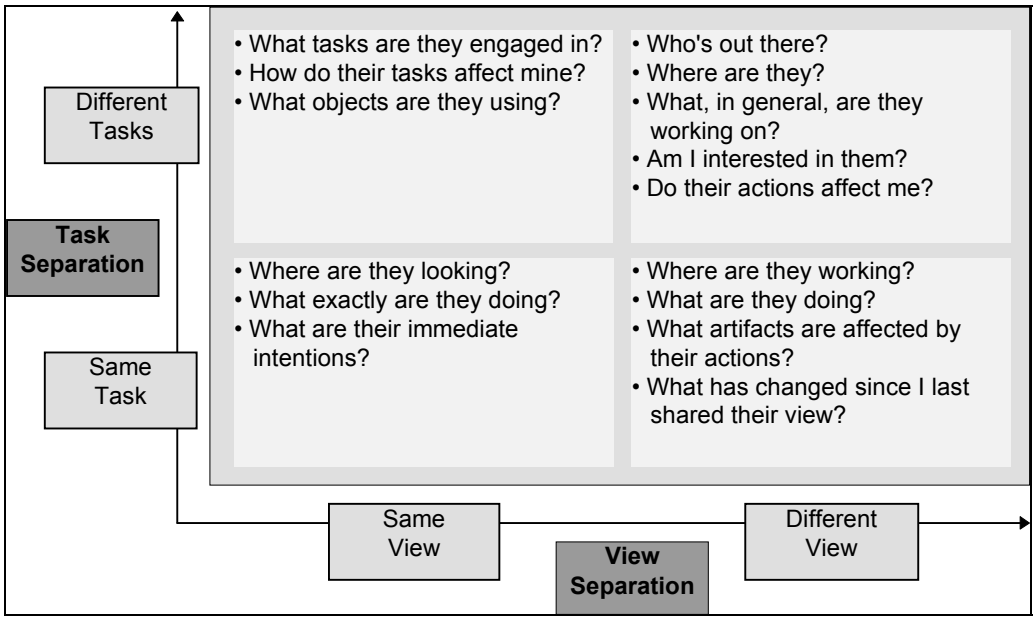

Figure 1. View and task proximity in collaborative situations

you see is what I see" or WYSIWIS (Stefik, Foster, Bobrow, et al. 1987), have a close view proximity. Those that allow each person to set their view to a different part of the worksurface (called "relaxed WYSIWIS") can have a wide separation. Figure 1 shows these two dimensions of group activity and lists some of the group awareness questions for each major area within the space.

As a group situation moves through this space, the requirements for group awareness also change. The framework suggests some underlying factors that account for these changes, including granularity of awareness, amount of interaction, and degree of synchrony.

Granularity. As tasks or views become increasingly different, the granularity of awareness also increases. In a situation where people work on the same task using the same objects, awareness is highly specific. Location information must indicate the exact object of another person's actions, and coordination of shared activity depends upon immediate awareness of the local effects of those actions. In a situation where tasks and focus are different, however, specific awareness is rarely useful. In the latter scenario, people require at most a coarse indication of who is present in the environment, their general location in the workspace, and their overall goals. This gives people a sense of what is going on, and of when to focus attention on another person's activities.

Interaction. The amount of interaction between participants decreases as either tasks or focus become separated. High-engagement situations near the origins of the two axes above have tightly interwoven interaction through visual, aural, and social communication channels and through common purposes. Large amounts of information can be transmitted, and a great deal of the participants' awareness of each others' locations, activities, and intentions is supported through this constant

communication. As direct interaction decreases, so does the amount of direct communication. The group must therefore rely on alternate means to inform them of others' activities.

Synchrony. As groups become separated through task or focus distance, people become less able to monitor all the changes that others make in the task environment. In some cases, this limitation forces them into a semi-synchronous kind of interaction. After a person does some work, they occasionally check on the past actions of others before they continue. The problem of maintaining incremental awareness is similar to that of understanding previous changes in completely asynchronous situations, except that semi-synchrony implies that the people who made the changes may still be present and actively working in the environment.

In order to further elaborate the framework and the varieties of awareness important to different situations, a few scenarios are described below.

Same task, same view. These situations involve close interaction and require detailed awareness of the other people in the group. The coarse awareness of location, presence, and character of activity that is important to other kinds of scenarios is taken for granted here. Beyond those basic forms of awareness, people observe gaze position, eye contact, inflection, facial expressions, and gestures to provide detailed information about the shared task. These situations are typically represented in groupware through a WYSIWIS view.

Same task, different view. Some tasks involve highly coordinated action but in entirely different places. For example, repairing a line in an electrical grid may require that two operators cooperate, each manipulating objects at the different ends of the line. In these situations, awareness is limited by distance but the need for awareness of the other person's actions is high, since the task at hand may depend entirely on actions taken in the other view. Traditional situations are sometimes forced into highly structured modes of verbal communication to prevent accident that could happen through lack of awareness. These situations correspond to distributed settings with relaxed-WYSIWIS views.

Different tasks, same view. In situations where group members work on different tasks, awareness of how things affect you can become more important than understanding what other people are doing or where they are. Information about constraints that affect a person's movement or action, the location of those restrictions, and who is responsible for what, are some of the specifics that should be known. This kind of situation occurs when people have different responsibilities within the same domain. For example, in the London Underground control room (Heath and Luff 1991), the person who makes public announcements about arrivals and departures and the person who actually controls the train schedules must be highly aware of one another in order to do their jobs effectively.

Some shared tasks, some shared objects, semi-synchronous interaction. This scenario highlights the differences in awareness requirements as synchrony decreases. The most obvious difference is that people need to know what has happened in a context since they were last there, for they need to bring their awareness of the environment up to date. This process involves finding out what is different, who was working in the area, how things got to be the way they are, and what the state of affairs is now with respect to my activities.

Different tasks, different objects. This scenario involves situations where people are doing different things in different regions of a shared environment. Examples include people independently exploring a sparse information space (such as the Internet), or the actions of two groups responsible for maintaining different aspects of a large shared structure. In these low-engagement situations, people need only coarse indications of presence and location, a global understanding of people's goals, and knowledge of long-range side effects. Making contact also becomes an issue: people in low-interaction situations may be looking for others with whom to collaborate and interact more closely (Cockburn and Greenberg 1993). To do this, awareness of people's general activities, interests, and goals is necessary.

3. Support for Group Awareness in a Groupware Toolkit

The framework described above identifies some group situations and the particular types of group awareness required for people to work effectively in those situations. Using the knowledge contained in the framework, we have begun to design and implement groupware that supports some of these needs. In particular, we are designing and building *awareness widgets* for our groupware toolkit, GroupKit (Roseman and Greenberg 1992). The following paragraphs describe three areas in which we have developed widgets and techniques to support group awareness.

Location awareness in different-view situations

Relaxed-WYSIWIS displays allow group members to set their own views into different parts of the shared workspace. In these situations, people should be kept aware of where others are working. We have designed two widgets that show people's locations: a multi-user scrollbar, and a gestalt-view display.

The *multi-user scrollbar* is illustrated on the right side of Figure 2 as part of a relaxed-WYSIWIS file viewer. The scrollbar supports group awareness by pinpointing others' relative locations within the common file. The right-most control acts like a standard scrollbar, and lets each user manipulate their own view. To its left is a vertical bar showing the relative viewport of all conference participants, each identified by a unique colour. The position and size of each bar is continuously updated as participants scroll through the document or change their window size. If the local user wishes to match their view with someone

else's view, they need only drag their scroller until it is level with the other's indicator bar.

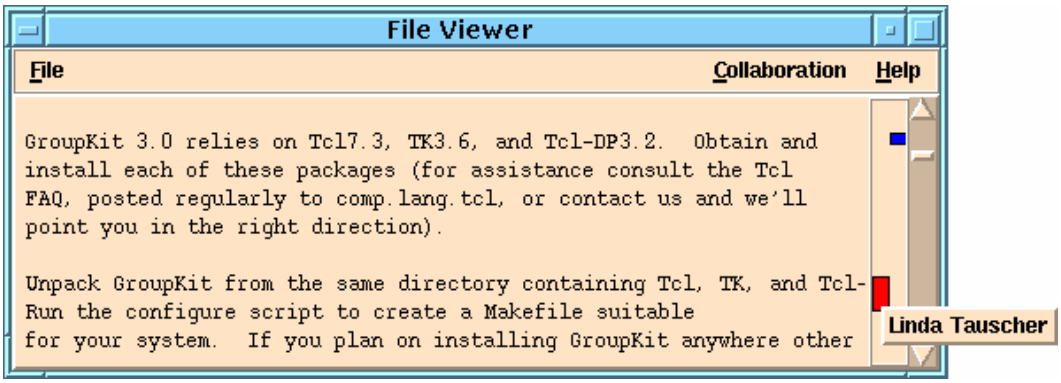

Figure 2. The multi-user scrollbar in a file viewer application

The *gestalt viewer* is similar in spirit to the multi-user scrollbars but is much richer in function. It works by presenting a miniature of the document overlaid with colored boxes that show the actual viewport of each participant in the session (Figure 3). These boxes are active interface objects: the user can scroll to a new location by dragging them with the mouse. The miniature preserves structural cues about the document that help a user better understand where their collaborators are working. As in the multi-user scrollbar, a person can make their view congruent with another by dragging their view outline overtop the outline of

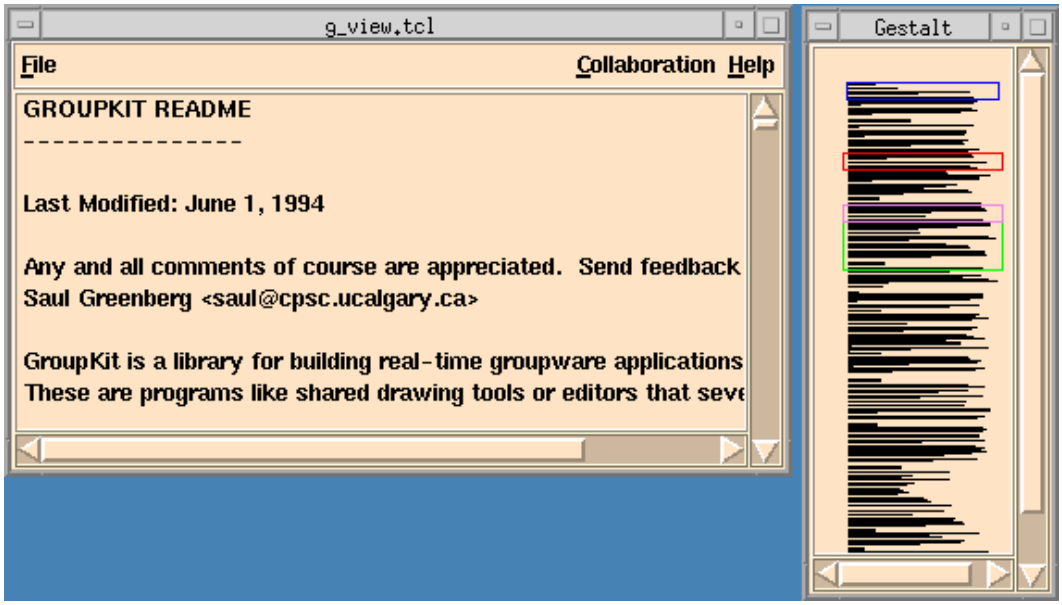

Figure 3. Gestalt-view display showing views on a list

another group member.

Awareness of Task Activity

Answering the question "what are the others doing?" is a crucial one for maintaining group awareness. The simplest means of supporting this need is to allow a person to see the others' actions, and determine for themselves what is happening. In same-view situations, this can be partially provided with multiple

cursors (Hayne, Pendergast, and Greenberg 1993), which show each person's pointer and their fine-grained movements on every screen. Multiple cursors allow gestural communication and give visual cues to a person's activity and intent. GroupKit's telepointer widgets are one implementation of multiple cursors, displayed in Figure 4 as cross-hatched circles.

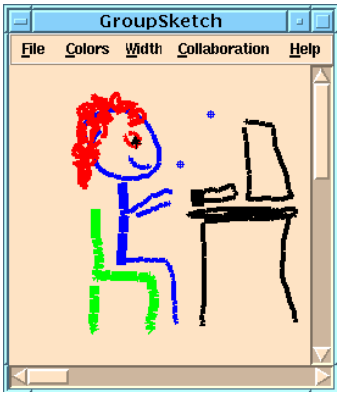

Figure 4. Telepointers in a group sketching application

In different-view situations, however, telepointers are of little value since they are not visible. In addition, limited screen space discourages the simple solution of showing complete duplicates of every person's view. Instead, we have prototyped a What You See Is What I Do (WYSIWID) widget. This widget displays only the immediate context around another participant's cursor, which is a subset of their view. This is illustrated in Figure 5, where a person sees not only his main view (of a network representation in this case), but also part of Saul's view (top right corner). The dynamics of the widget is that the remote view is always centred around their cursor; Instead of showing cursor movement, the background is panned instead. Since most actions in graphical applications involve the mouse cursor, the local-view display can show what others are doing in a limited space.

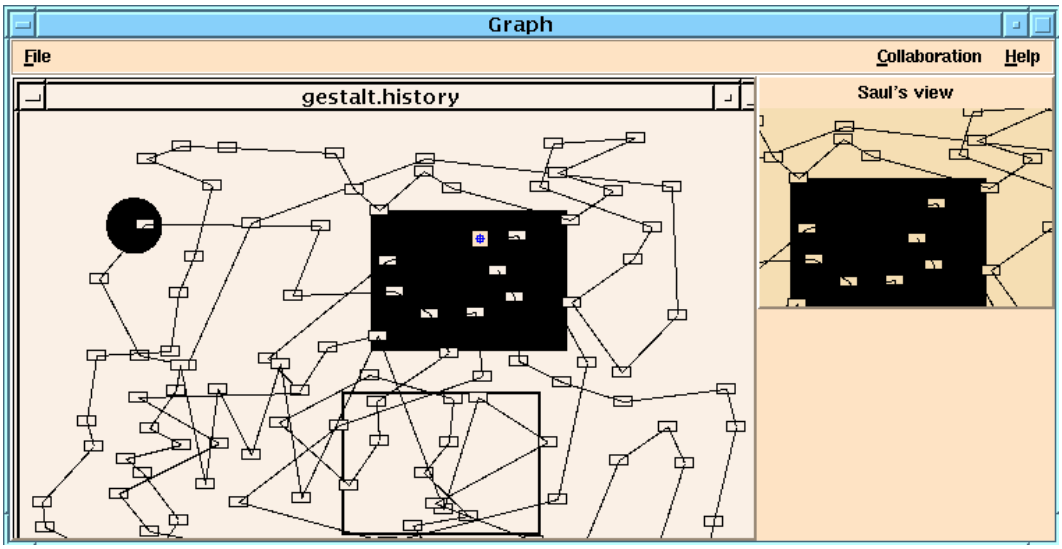

Figure 5. A Local-view (WYSIWID) widget showing a network

Group awareness in semi-synchronous situations

Group awareness of the near past involves finding out what others have done, where they have been, and what they have changed. Tools like change bars or "diffs" can provide only some of this information, and only for some types of documents. We have designed a few widgets to experiment with supporting

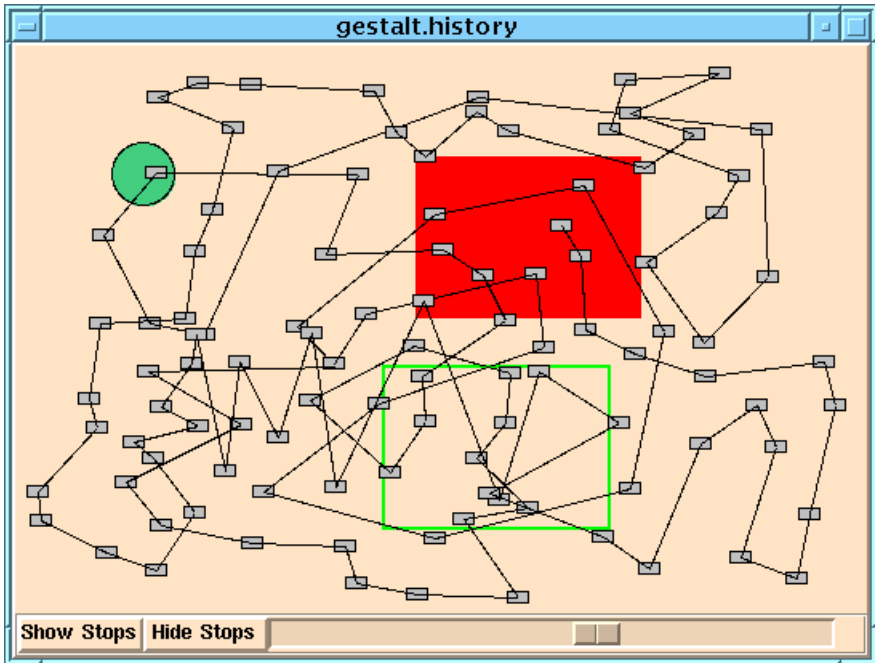

Figure 6. The historical gestalt-viewer in a graph browser application.

awareness of a group's recent actions. Consider a variation of the gestalt viewer as shown in Figure 6, where a miniature of a graphical browser is displayed.
As well as showing another person's current viewport, the widget allows a user to trace where others have been in the workspace through a history mechanism. Moving the slider at the bottom of the window plays back the movement of another person's viewport (displayed as a moving outlined rectangle), and also indicates where they stopped for a while (shown as a filled rectangle).

Our second prototype implements a technique for indicating whether or not any changes have happened since the last time a user has attended to the display. In an early version of a textual chat application, we noticed that it was too easy to miss a contribution if there were more than two people in the conversation, or if some time had gone by since a person has looked at the display. Our new version of the text widget indicates changes since a previous interaction. Figure 7 shows a three-way conversation as viewed by Carl Gutwin who types into the top window. The highlighted text in the other windows is "new," in that it has appeared since the last time Carl typed in his window. When Carl resumes typing, the highlighting in the other windows disappears; the assumption being that the highlighted text has now been seen. Although marking and aging of changes has been implemented in other systems (Ellis, Gibbs, and Rein 1992), our design allows the idea of "age" to be determined by events other than the passage of time, which makes the technique more suitable for a variety of situations.

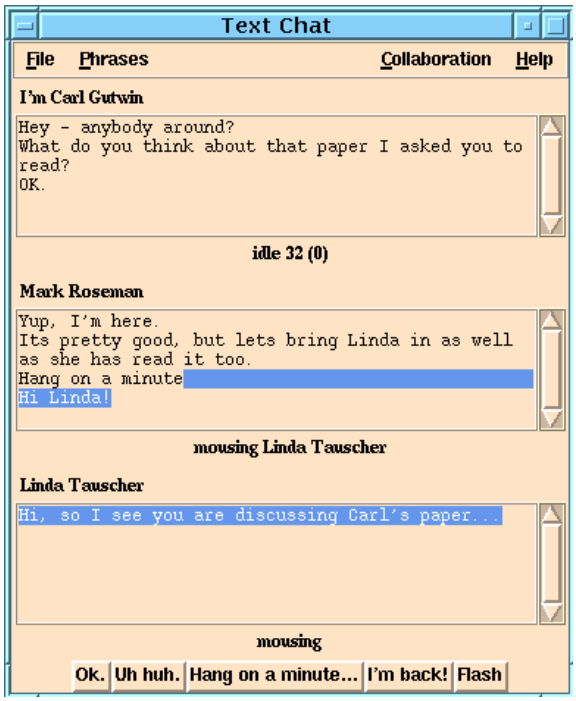

Figure 7. Highlighting of recent text

4. Summary and plans for future research

Although group awareness has not been extensively considered in CSCW research, a handful of other people have implemented tools to support aspects of awareness. For example, the GroupKit multi-user scrollbars and global views were inspired by the ones in the SASSE text editor (Baecker, Nastos, Posner and Mawby 1993), and multiple cursors have a lengthy history (e.g. Engelbart and English 1968; Stefik, Bobrow, Foster, et al. 1987; Greenberg 1992). Change-aging was introduced in the GROVE editor (Ellis, Gibbs, and Rein 1992). Other awareness inventions include activity indicators in Colab (Stefik, Bobrow, Foster, et al. 1987), "flexible diffing" (Neuwirth, Chandhok, Kaufer, et al. 1992), and various forms of playback and change tracking (e.g. Crowley and Forsdick 1989; Greif 1992).Aside from stylistic differences, the major advantage of the GroupKit implementation is that the techniques are developed as reusable, generalised widgets that a developer can easily include in a groupware application.

Our framework is a first step in moving what was largely an ad-hoc approach to group awareness to a more principled one. As well, we are identifying issues that affect both the design and use of techniques for supporting the maintenance of group awareness. Among these are:

- the trade-off between being well informed about others' activities but being distracted by that information from the task at hand;
- the difficulty of determining what information is crucial for maintaining group awareness in particular situations;
- the difficulty of transmitting a literal representation of an activity between participants whose views of the workspace differ considerably;
- the need to support people's ability to exert some control over the awareness information that others receive about them;
- the question of going beyond existing face to face practises, where new awareness mechanisms can augment, rather than just replace, what people normally expect.

The next stage of our work will test and extend the ideas presented in this paper. We will use the framework and the issues above to refine existing widgets and design new ones. Of course, the widgets presented here are work in progress and have not been rigorously tested; we will evaluate them and use the results to adjust the framework and to feed the iterative design of new groupware interface components.

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