Supporting Awareness among Virtual Teams in a Web-Based Collaborative System: The TeamSCOPE System

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ABSTRACT

This paper overviews a Web-based collaborative system called TeamSCOPE that has been designed to support awareness needs of globally distributed teams. Four types of awareness needs of virtual teams are defined and the awareness support features of TeamSCOPE are described. The use of TeamSCOPE in a project involving a number of globally distributed engineering design teams is outlined, and evaluation results are provided. Findings illustrate how group process interacts with technology to create design challenges in the support of virtual team awareness needs.

INTRODUCTION

Two years ago, we began an NSF-sponsored research project studying communication and coordination in globally distributed engineering design teams, building on two prior years of work on such virtual teams. This project, known, as INTEnD (International Networked Teams for Engineering Design) involves forming teams of engineering students from schools in Asia, the U.S. and Europe to work on industry-sponsored design projects over a 4 month period. Most teams never meet face-to-face across locations, and rely on email, ISDN video-conferencing, and Internet-based collaboration tools such as NetMeeting to support their work [5, 8]. In late 1998 and early 1999, we developed a Web-based collaborative system (Wbcs) called TeamSCOPE to respond to a number of information problems experienced by the virtual teams we studied [9]. Many of these problems were similar to those reported by other virtual team investigators who focus on the information and awareness deficits caused by lack of co-location [1]. One simple, but crucial need of the teams was to have a common "place" where work could be accessed and archived. We explored other Wbcs's available at the time to support our project. However, we concluded that, although those systems offered a shared virtual space for storing group documents with support for co-authoring, they did not satisfy all of the awareness deficits our teams were experiencing. We thus built our own system emphasizing the awareness needs of virtual teams as the central design principle. In this paper, we elaborate on these awareness requirements, describe the features we implemented in TeamSCOPE to support awareness, and offer a brief comparison on awareness features between TeamSCOPE and other systems. Finally, we review what we have learned over the past year of TeamSCOPE use, evaluation, and continued development.

CONCEPTUALIZING AWARENESS

The concept of awareness means many things to many people, with one paper describing nineteen different types of awareness information [2, 3, 4, 10]. Our observations led us to focus on four specific types of awareness deficits suffered by the virtual teams we studied [9]. First, participants often complained that they did not know what their remote teammates were doing vis-a-vis the project on a day-to-day basis. The extra effort needed to update distant partners, as well as the delays from sending email across large time zone differences contributed to this. This represents a lack of awareness about others' *activities* (what are they doing). Second, we noticed that teams floundered without real-time communication, but had difficulties scheduling and coordinating synchronous group meetings. They lacked awareness about each other's *availability* (when can I reach them). Third, because of the differing local institutional requirements and calendars, team members often did not fully understand what their remote partners' key deadlines and task requirements were, and how this impacted their own tasks. These kinds of problems stem from a lack of awareness about *process* (where are we in the project). Finally, groups often complained that they did not really understand why remote teammates failed to take up a suggestion, or how they thought about a particular contribution. Even when they did respond, it was not always clear how to interpret these responses due to differences in training, backgrounds, institutional contexts, etc. We have considered this to be a lack of *perspective* awareness (what are they thinking and why).

IMPLEMENTATION OF AWARENESS FEATURES

TeamSCOPE contains a number of features that explicitly address the above awareness deficits. These include:

- **File Manager.** A shared file space allows team members to upload documents, drawings, images, etc. (Figure 1) Team members can review a file's history to see who else has accessed it to support activity awareness (Figure 2), and comments can be attached to

any file or folder to support perspective awareness. Moreover, the system tells users who else has read the comment (Figure 3).

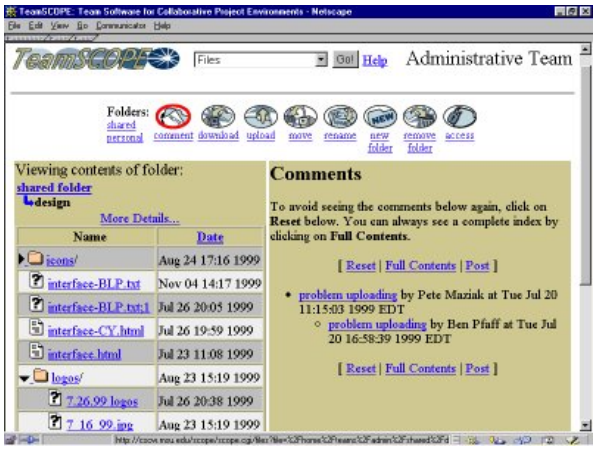

Figure 1. The TeamSCOPE Final Manager

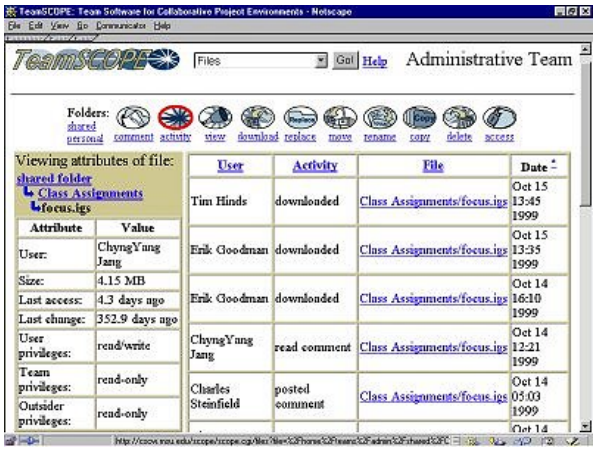

Figure 2. File Activity History

Figure 3. Comments Attached to Files

- **Message Board.** Groups can hold threaded discussions on a message page to support perspective awareness. As with comments attached to files, each message posting also reveals who else has read it (Figure 4).

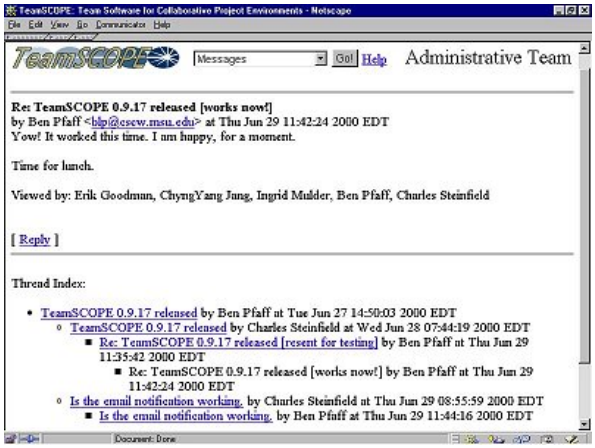

Figure 4. The TeamSCOPE Message Board

- **Calendar.** Groups can note critical dates on a calendar, and provide detailed descriptions of the event (Figure 5). This supports process awareness. They also can indicate if any shared resource (such as the ISDN video-conferencing station in our lab) is required, and the system will automatically flag a potential resource conflict.

Figure 5. The TeamSCOPE Calendar Page with an Event Detail

- **Activity Summary.** Direct support of activity awareness comes from a system log of all activities in the team's directory, which is posted into a database. The default screen after login is a summary of all recent activities, including file uploads, comments and messages posted, and calendar entries. User's accesses to all entries are also recorded and displayed. Objects are provided as links, so that team members can go immediately to them once they are aware that something has happened (Figure 6).

Figure 6. Recent Activity Summary

- **Activity Notification.** An optional feature is that users can configure their account to have activity notifications sent via email, at the time interval of their choice (Figure 7). They can optionally set filters on these notifications.

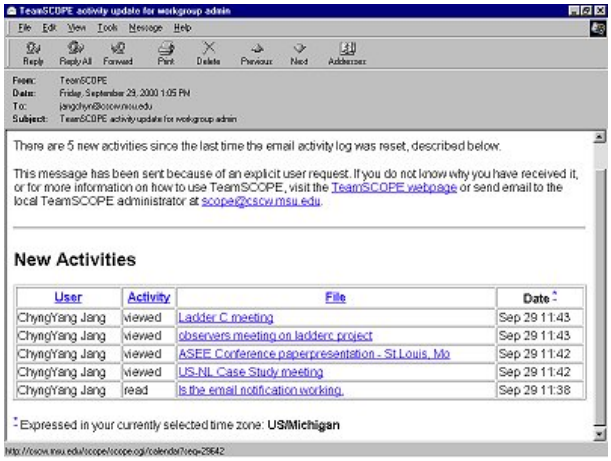

Figure 7. Email Notification of Activities

- **Team Member Login Status.** At the head of every page in TeamSCOPE is a notification of who else on the team also happens to be logged in (defined as having accessed a page within the past x minutes). To exploit this availability awareness, a synchronous chat feature is provided (Figure 8).
- **Team Member Usage Information.** A user information page allows team members to review each other's login history over a specified time period. It supports availability awareness by offering a graph of what times of day others have connected in the specified time period. This is displayed in the querying users local time to help them predict when they might find another user online (Figure 8).

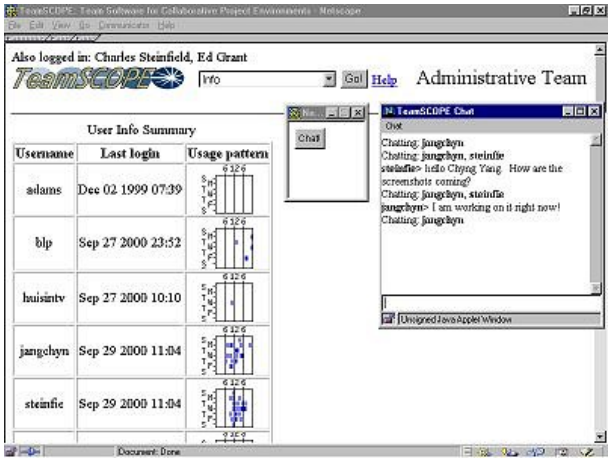

Figure 8. Communication Availability Support: Login Status, History, and Chat Windows

- **Team Summary Site**. A dynamically created team web page is available that provides a quick summary overview in one screen all recent file, message and calendar entries for the week (Figure 9).

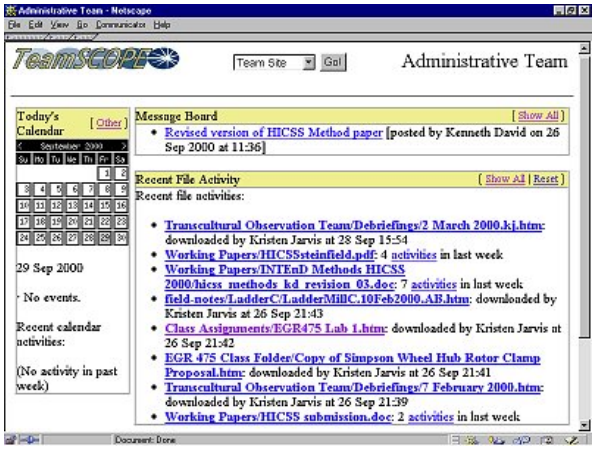

Figure 9. TeamSCOPE Team Summary Site

COMPARISON WITH OTHER Wbcs

A lot of Wbcs have emerged or been improved since we began to develop TeamSCOPE. Like TeamSCOPE, many of them offer a similar bundle of collaborative functions, including shared file space, threaded discussion board, calendar, file annotation, active user monitoring and text-based chat. However, the support of awareness information varies among different systems. Here we look at four systems, including BSCW (bscw.gmd.de), eRoom (www.eroom.com), eCircle (www.ecircle.com), and TeamSCOPE, and offer a brief comparison along three dimensions regarding the provision of awareness information.

Types of Awareness Information Provided

In terms of activities on shared objects, all these systems offer notification of changes of shared objects, including

new additions, modifications and deletions. BSCW and TeamSCOPE also provide the access records of shared objects, such as who read a message and who downloaded a file. In addition, systems have their own unique ways of supporting group awareness. BSCW allows users to indicate their attitude or call attention when they post messages by selecting from a preset list of message types and accompanying icons to messages accordingly. eRoom shows the project status with a traffic light icon up front after users log in. TeamSCOPE provides users their teammates' login pattern.

Organization of Awareness Information

BSCW and eCircle exemplify two different approaches to organizing activity awareness information. In BSCW, events are presented strictly according to the structure of shared objects. In both its web page and email notification, activity records are inserted under the corresponding items in the hierarchical file structure. It gives a reference point for the user to make sense of the information and also promotes a mental map of the shared space. On the other hand, in eCircle , all new happenings are listed according to their temporal order. It provides a sense of history and can help users reconstruct the sequence of events. TeamSCOPE's approach is somewhat in between. The activity summary is presented chronologically in TeamSCOPE by default with options allowing users to sort the information according to the user name, object name or the type of activity. It gives users a little more flexibility in the way they view awareness information.

Delivery of awareness information

Three channels have been utilized in these systems to deliver awareness information: web pages, emails and java applets. TeamSCOPE presents an activity summary right after users log in. Both eCircle and eRoom begin their front page with user-post announcements. In addition to presenting the awareness information on the web, all four systems also send out email notifications on changes in the workspace with different levels of customization regarding the frequency and contents of the notification. Moreover, users of both eRoom and BSCW can take advantage of a plug-in java application for receiving real-time alerts on events, announcements or teammates' log-in status. TeamSCOPE and BSCW both enable users to search the event history database for particular activities.

In summary, TeamSCOPE and BSCW provide a more complete set of awareness information. While BSCW organizes the events according to the workspace structure, TeamSCOPE gathers activity records in a central location and offers some flexibility for users to structure event summaries according to their own needs. However, TeamSCOPE has not yet incorporated any real-time component that allows the server to push awareness information onto users' desktops.

USAGE OF TeamSCOPE

TeamSCOPE has primarily been tested on a series of distributed student engineering design teams participating in the above-mentioned INTEnD project. INTEnD was initiated by Michigan State University (MSU) as an open consortium of universities for the purposes of cooperating on the formation and study of global virtual teams. Participating universities in the past two years include Delft University of Technology in the Netherlands (TUD), St. Petersburg State Technical University in Russia (SPSTU), Universidad Carlos III in Madrid, Spain (UC3M), and Tsinghua University in Beijing, China (THU). This fall we are also working with three campuses of the Monterrey Institute of Technology in Mexico. Teams are formed by having one or more engineering faculty at each of the schools recruit students to work on a design project. Engineering faculty work with the students as design project supervisors, providing advice and evaluating work. Faculty recruit industry partners from firms with an engineering design project that they are willing to give to a student team. Industry partners had to agree to be the "client" for the student team. Students are upper level undergraduates or beginning graduate students in various engineering majors. They are told they will be working on an international student team. Teams work with each other in English, and students have to possess English language skills to work on the projects.

Most teams consist of four to nine members from two locations. All are zero-history teams, formed at the start of a semester, and they work over an approximately four-month period to complete their designs. A full working version of TeamSCOPE has been provided to all teams since the start of the fall 1999 semester. In addition, teams are provided with email, telephone, fax, and Netmeeting, and a subset also are able to meet with their remote counterparts via PC-based ISDN video-conferencing. In addition to the student teams, the various faculty and research personnel involved with INTEnD each semester are given accounts on TeamSCOPE to help coordinate their activities.

Since fall of 1999, eight student teams have used TeamSCOPE. For each of these teams, we have collected data for evaluation purposes. We describe the TeamSCOPE evaluation in the next section.

Evaluation Methods

Three types of data form the basis of our evaluation of TeamSCOPE:

- System logs tell us the frequency with which individuals used TeamSCOPE across the lifespan of their projects, as well as the degree to which various sections of TeamSCOPE were used.
- A questionnaire administered at the close of the project asked participants to rate TeamSCOPE's ease of use and usefulness for achieving a variety of functions. We also asked several general questions to tap

participants' perceived level of awareness of their distant teammates' activities.

- Open-ended interviews with teams and observations of teams in action provided qualitative information for the evaluation.

Evaluation Results

System logs reveal somewhat variable usage of TeamSCOPE across teams. The research on collaborative technologies consistently finds that groups adopt and use such tools in their own group-specific ways [7]. Variation in usage is evident in the frequency of use of awareness specific features and in the distribution of use among individuals within teams. We looked specifically at the usage of activity summaries, the calendar and the user login information feature as the subset of TeamSCOPE features that focused the most heavily on provision of awareness-related information. About half of the teams experimented with TeamSCOPE at the outset of their project, but usage diminished considerably and tailed off towards the end of the period. Figure 10 illustrates this distinction between teams that were heavy and light users of awareness-specific features. In some teams, usage was highly concentrated among a minority of team members (e.g. teams 6 and 8), while in others it was quite evenly distributed (e.g. teams 2, 5 and 7, Table 1). Summaries of page requests show most hits occurring on the file management page, followed by activity summary, and message board (Table 2). Relatively few requests on average were made for the calendar and user login information pages, or other pages (such as options or search pages). Interviews and observations help us to explain these different usage patterns. For example, we know that in several teams, group members explicitly decided to centralize file management among one or two individuals. Although this helped to maintain order in the file structure, the decreased usage by others resulted in an overall loss of awareness. In addition, in locations with two or more people, often students came together to the lab and sat together in front of a workstation to check TeamSCOPE for remote teammate activity. Team awareness increases, but it creates artificially lower and less distributed TeamSCOPE use.

Table 1. Within-team TeamSCOPE Usage Distribution

Team ID*	Team size	% of use: top two users
1. CS	6	61%
2. LA	5	54%
3. LB	5	64%
4. LC	7	61%
5. PR	7	42%
6. RW	9	78%
7. WA	8	47%
8. WB	7	85%

*The two letter Team ID is derived from the groups' task.

Table 2. Average Weekly Individual Usage of TeamSCOPE Pages in Each Team

Team ID	File Management	Message Board	Calendar	User login info	Activity-awareness related**	Others***	Total
1. CS	10.25*	12.24	4.07	.56	7.81	1.78	36.71
2. LA	65.07	5.87	6.67	.90	16.40	2.01	96.92
3. LB	54.72	6.78	6.33	1.60	11.63	2.17	83.23
4. LC	28.49	2.44	1.39	.32	3.89	1.05	37.58
5. PR	6.61	.99	1.46	.26	.81	0.46	10.59
6. RW	20.21	1.41	1.22	.05	2.09	1.05	26.03
7. WA	20.99	3.20	4.51	.52	5.95	1.28	36.45
8. WB	26.77	2.36	1.88	.52	5.42	0.8	37.75
Average	26.50	3.93	3.10	.51	5.94	1.23	41.21

* mean number of page requests per group member per week

** including login, activity summary and activity search

*** including various option setting features and help

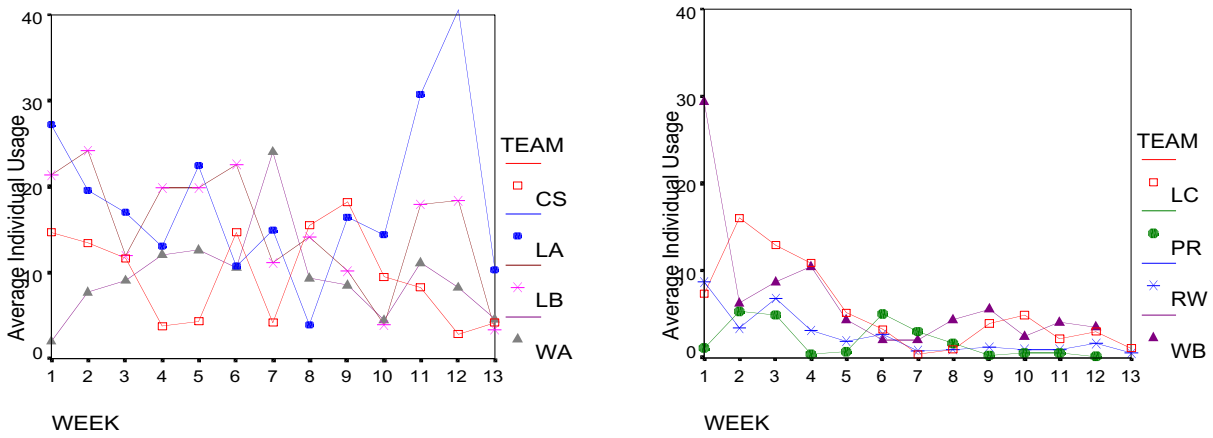

Figure 10. Teams Exhibiting High (left graph) and Low (right graph) TeamSCOPE Awareness Specific Usage Across Time

Questionnaire data reveal that nearly all groups rated the shared file space as the most useful feature, suggesting that having a shared repository for distributed group work is essential (Table 3). Most did not find the calendar to be that useful. Ratings for other features varied among groups. For example, groups 3 and 4 rated the Activity Summary much higher on the usefulness scale than other teams. Again, we relied on interviews and observations to understand these differences. For example, we learned that in groups 3 and 4, some participants questioned whether remote teammates were truly devoted to the project. They frequently inspected TeamSCOPE activity summaries to see if their distant teammates were really working or not. Indeed, in Team 4, users in one location were able to confirm their suspicions that distant teammates were ignoring uploaded files until minutes prior to a real-time meeting, exacerbating trust problems in the team [2].

Table 3 also shows that in most teams, students report little trouble using TeamSCOPE. However, our interviews and observations do reveal aspects of TeamSCOPE use that students found difficult to master. One critical problem teams faced was organizing a directory of shared files. We did not provide a default directory structure, and team members rarely decided ahead of time on one. Instead, each individual created new folders when it seemed appropriate, making it hard for others to navigate through files. This was not a problem early in the project, since participants would learn of a new file from the Activity page, and then go directly to it. However, later on, when the number of activities was much larger and when participants wanted to review older files, the lack of a consensual directory structure clearly made finding and organizing files difficult. As Mark and Prinz [6] pointed out from their experience in PILOTeam project, conventions for naming and file structure are needed for groupware use.

Finally, we mention five additional insights about the usefulness of TeamSCOPE based on our interviews and observations:

- Inherent ambiguities in the nature of the awareness information supplied limited its usefulness for teams. For example, individuals told us that although they could tell when their work had been downloaded by distant teammates, they did not know if others actually read it carefully and understood it. This only became evident in subsequent interactions. Yet there was a tendency to "read too much" into a simple download.
- Supplying detailed awareness data can have quite opposing effects. In one team (team 2), the communication availability information was extensively used to coordinate real-time meetings. The group made appointments for a video meeting, then logged into TeamSCOPE at the meeting time. When they saw the distant teammates logged in, they opened a chat session, and clarified that the others were ready to receive a video call. On the other hand, the two teams noted above who used the awareness data to verify inaction by distant teammates illustrates a quite different outcome from awareness data. In general, we see strong *reinforcement* effects - teams functioning well in other aspects used TeamSCOPE productively, while teams functioning poorly in other aspects aggravated problems through TeamSCOPE use.
- Despite the obvious advantages of relying on shared files and public postings, groups continued to exhibit a preference for regular email. On many occasions, attached files were sent to all teammates rather than uploaded, and emails were almost always preferred over message postings. Groups did not like having to log in and check an additional application beyond their email.
- Use of TeamSCOPE is subject to critical mass effects. That is, if some on the team choose not to use it, then all must resort to email if they wish to disseminate work. Hence, rather than duplicate efforts, all stop using TeamSCOPE.

Table 3. User Evaluations of TeamSCOPE Features*

	Usefulness						Ease of Use	
Team ID	Shared File Space	Message Board	Calendar	Activity Summary	User Info	Average	Find new objects**	Perform actions***
1. CS	3.50	3.33	2.00	2.80	2.80	2.89	4.57	4.22
2. LA	4.20	1.60	1.60	3.00	2.25	2.53	4.05	4.4
3. LB	4.60	3.60	2.80	4.20	3.40	3.72	4.7	4.63
4. LC	4.57	2.57	1.29	4.71	2.86	3.20	4.43	4.22
5. PR	2.50	2.00	1.83	2.33	2.17	2.17	4.04	3.33
6. RW	3.11	1.89	1.44	1.67	2.44	2.11	3.91	3.18
7. WA	4.13	3.00	2.88	3.25	3.43	3.34	4.03	3.92
8. WB	4.75	3.50	1.50	2.67	3.67	3.22	4.29	3.96
Average	3.92	2.69	1.92	3.08	2.88	2.90	4.25	3.98

* ratings are on five point scales with 1= not useful or not eacy to use at all, and 5= very useful or very easy to use

** average ease of finding info. about uploads, downloads, who read messages, and when others used TeamSCOPE

*** average ease of use of uploading files, locating and downloading files, posting messages, and posting calendar events

- Task interdependence clearly influences reliance on TeamSCOPE. Several groups organized their project work in such a way as to minimize interdependence with remote teammates. This not only reduced vulnerability to non-performance by the remote counterparts, but it also lessened communication overhead. When teams used a division of labor approach, there was less value in having frequent and detailed awareness data.

CONCLUSIONS

Based on our experiences, we are continuing to refine and add to TeamSCOPE features. For example, because of the continued preference for email, we have now added an email gateway to TeamSCOPE. That is, when someone elects to have email notification of TeamSCOPE activities, two new features reduce their effort in responding. First, all activity notifications arrive in html-capable mailers as links, so that recipients can quickly connect to TeamSCOPE and review the material in question. Second, if the activity is a message or comment, it arrives as an email to which users can respond. The response is automatically posted as a reply on TeamSCOPE. Other Wbcs such as eCircle are now also implementing this capability.

We also are attempting to address obvious limitations in our calendar by enabling groups to import data from project planning software, to avoid the problem of redundant entry of schedules.

In summary, TeamSCOPE represents a Web-based collaborative tool that was specifically designed to support awareness. We recognize that such tools must be complementary to other communication and coordination tools and that multiple sources and types of data are essential to improve iterative design efforts.

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