

Notification for Shared Annotation of Digital Documents

A.J. Bernheim Brush¹, David Barger, Jonathan Grudin, and Anoop Gupta

Microsoft Research
One Microsoft Way
Redmond, WA 98052

ajb@cs.washington.edu, {davemb, jgrudin, anoop}@microsoft.com

ABSTRACT

Notification and shared annotations go hand-in-hand. Notification of activity in a shared document system is known to support awareness and improve asynchronous collaboration, but few studies have examined user needs and explored design tradeoffs. We examined large-scale use of notifications in a commercial system and found it lacking. We designed and deployed enhancements to the system, then conducted a field study to gauge their effect. We found that providing more information in notification messages, supporting multiple communication channels through which notifications can be received, and allowing customization of notification messages are particularly important. Overall awareness of annotation activity on software specifications increased with our enhancements.

Keywords

Notification, annotation, annotation system design

INTRODUCTION

Shared annotations on digital documents are an attractive means of asynchronous collaboration: Commenting in context reduces the writing required; readers benefit by seeing comments alongside the original document. As an effective means of communication, however, annotations have a major flaw: Interaction is primarily between person and document, not person and person. As a result, communicating ideas is often slow and cumbersome. People must revisit a document to see the latest comments.

One way to address this problem is to integrate a notification mechanism into a shared annotation system. When a new annotation is added, interested parties are notified (e.g., by email) and can revisit a document to read more, add a reply, or contribute new comments. Several systems (e.g. [2] [6] [10] [12] [13] [15]) have used this approach with varying degrees of success. Email notifications are common in commercial systems.

Although notification mechanisms in shared annotations systems are common, there has been little study of user needs and little exploration of design tradeoffs. This paper's primary contribution is to take those steps. First, we report on the current usage of notifications in Microsoft

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee.
CHI 2002, April 20-25, 2002, Minneapolis, Minnesota, USA.
Copyright 2002 ACM 1-58113-453-3/02/0004...\$5.00.

Office Web Discussions [15], a shared annotation system that includes a closely-integrated notification mechanism. Informed by this study, we designed and deployed improvements to the notification mechanism that include more detailed email notifications and notifications using peripheral awareness.

We discuss related work in the next section, and then describe the use of notifications in Office Web Discussions. Next we outline design considerations for an effective notification mechanism and notification enhancements we made to Web Discussions based on these considerations. We then describe a field study of our notification enhancements. We conclude with implications for the design of annotation notification mechanisms.

RELATED WORK

Awareness and notifications have long been recognized as important aspects of both synchronous and asynchronous document collaboration systems. A study of collaborative writing by Baecker et al. [3] stressed the importance of mutual awareness, knowledge of the state or actions of collaborators. Dourish and Bellotti [7] discuss the importance of passive awareness, "an understanding of the activities of others, which provides a context for your own activity" ([7]). More recently a large scale study of activity in BSCW [1], a groupware system that supports shared workspaces, identified awareness features as the second most common group of operations used by frequent users.

Awareness of Document Activity

Document collaboration systems and document annotation systems support awareness in three main ways: by providing information about what has changed since the last visit, by allowing subscription to explicit change notifications, and by providing peripheral awareness.

Informational

Information about changes that have occurred since a person last visited can be generated automatically or by using comments explicitly entered when a change is made.

In BSCW [2], icons indicate recent document activity: reading, editing, or versioning. Clicking on the icon retrieves information about time and actor. Other document systems, like Lotus QuickPlace [14], provide similar change information explicitly on a separate web page.

POLiwaC [8] also uses icons (and colors) for the lowest of its four intensity notification mechanisms. As the intensity

levels increase, the user is notified with enlarged icons, scrolling messages and dialog boxes. POLiwaC supports synchronous and asynchronous notifications. People in a shared workspace can be notified immediately or the next time they enter it.

The Annotator [17] and ComMentor [18] annotation systems allow people to search the set of annotations made on a document. This provides information about new annotations, but requires additional work by the user.

Informational methods update users on what has happened since their last visit, but rely on use of the system to discover changes. The notifications we study in this paper are subscription based and inform users automatically of changes that have occurred.

Subscription based

Many document collaboration and annotation systems that provide notifications (e.g. Quilt [12], Crit.org [6], Web Discussions [15], Intraspect [10], BSCW [2], Livelink [13]) allow users to subscribe to changes on documents, on folders, or specifically for document annotations. Users typically choose whether to be notified immediately or receive a daily or weekly bulk notification. The notifications are primarily delivered using email. Quilt [12] allowed users to specify the degree of change -- for example, substantial -- that they want to be notified about. Users of Intraspect [10], an enterprise collaboration system, can also be notified about changes via their personal web pages. It includes a "Tell People" function that allows a user to send email notifications directly to other people. We study the Web Discussions [15] notification mechanism in more detail in this paper.

Peripheral Awareness

Dourish and Bellotti [7] discussed shared feedback that passively distributes information about individual activities to others in a shared workspace. For example, each user of ShrEdit, a multi-user text editor, has a cursor within a shared window and can thus see what others are doing. Gutwin et al. [9] have studied 'awareness widgets' such as miniature views in shared workspace groupware systems. BSCW provides an EventMonitor that can be used for realtime presence and activity awareness [11]. These systems focus on synchronous collaboration; Dourish and Bellotti suggest that information available peripherally might be valuable in semi-synchronous systems that support both synchronous and asynchronous work modes.

Our work focuses on notifications for an asynchronous document annotation system, but provides awareness through information that is always peripherally visible. This resembles the visibility at a glance available in the synchronous environments described above.

Studies of Notifications for Annotations

A recent study of BSCW found that awareness features are very popular [1]. Awareness information was more often used by frequent users of the system than other users. The authors suggest that it takes time to adjust to the features used to co-ordinate asynchronous work.

Cadiz et al. [4] observed the use of the Microsoft Office 2000 Web Discussions annotation system by about 450 people over a 10-month period. They mention the use of email notifications: Some users felt that they checked the document enough and did not need notification; others wanted notifications with more detailed information about the content of new annotations.

The prevalence of features to support awareness suggest its importance for collaboration around documents, but there are few studies of awareness features, and very few of notifications in shared annotation systems. This paper means to redress this imbalance.

USAGE OF WEB DISCUSSIONS NOTIFICATIONS

To better understand current practice, we studied the recent use of the Microsoft Office Web Discussions annotation system [15] by a large software product development group, focusing on their use of the default notification mechanism built into the system. We also surveyed a subset of users to assess their experience with the default notification mechanism.

The product group uses Web Discussions to comment on software feature specification documents, or "specs." Program managers (PMs) are responsible for writing specs that are subsequently commented on by the developers and testers who will implement and test the features. Others, including documentation and usability specialists, also comment on the specs.

Web Discussions

The Web Discussions annotation system allows annotation on any web page. An annotated web page is shown in Figure 1. The annotations are displayed inline in the page and replies are indented. Annotations are created by clicking a button in the Web Discussions toolbar at the bottom of the browser window. This displays icons on the page where annotations can be added. Clicking on an icon brings up a dialog where a user can type in an annotation. Users reply to an annotation by clicking on the icon at the end of an annotation.

Annotations made using Web Discussions are stored on a separate annotation server. The server resides on an

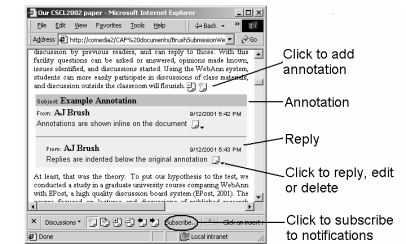


Figure 1. A web page annotated with Office Web Discussions.

¹ Current address: Computer Science and Engineering Dept., University of Washington, Seattle, WA 98195

organization's intranet. When a user with appropriate server permissions browses to a web page with Web Discussions turned on, annotations for that page are downloaded and inserted into the local version of the web page. Thus, using Web Discussions does not modify the original HTML version of the web page. See [4] for more details of the Web Discussion interface.

Notification Mechanism

Web Discussions includes a simple default notification mechanism. By clicking on the "subscribe" button in the Web Discussions toolbar users can receive email when annotations on the document are made or modified. Users can have email sent for each change or receive a daily or weekly summary. An example of the change notification email is shown in Figure 2.

Cadiz et al. [4] found several significant drawbacks to this mechanism. For instance, it does not identify which annotations have been added or make it easy to follow-up on the discussion. Subscribers cannot control notifications based on who made annotations (e.g. someone replying to an annotation made by the subscriber, or the document author). And it does not inform annotators as to who will be notified automatically of annotations.

Usage Analysis

We analyzed usage of Web Discussions for a six-month period from February through August of 2001. During this time, 466 users made 13,780 annotations on 851 documents. Each user created an average of 29.6 annotations on an average of 4.9 documents. Each document had an average of 16.2 annotations made on it and 1.35 subscriptions for email notification of Web Discussion events (adding comments, deleting comments, modifying comments, "resolving" a comment, and so on).

Users and Notifications

Users of Web Discussion notifications fall into three groups: 348 made annotations but did not subscribe to notifications, 118 annotated and subscribed, and 48 subscribed but did not annotate. Thus, 75% of users did not receive notifications.

118 users both annotated documents and signed up for a total of 562 notifications subscriptions on 415 different documents, for an average of 4.76 subscriptions per user. 234 of these 415 documents were annotated. Daily subscriptions were preferred. 328 (58%) of the 562 subscriptions were for daily notifications, 224 (40%) were for immediate notifications and 10 (2%) were for weekly notifications.

The 48 users who received notifications but did not annotate averaged 4.9 subscriptions. Collectively they held 237 subscriptions to 200 documents. Daily subscriptions were again the most popular, comprising 138 (58%) of the 237 subscriptions with 98 (41%) immediate subscriptions and 1 weekly subscription.

Table 1. Average replies and median response time (MRT) for different classes of subscribers.

Subscription	Replies	MRT (days)
daily	28.61	1.14
immediate	20.97	0.90
none	11.12	0.78

Responsiveness

In general, as Table 1 illustrates, users who subscribed made significantly more replies than those who did not ($t(258)=3.86, p < 0.001$ for daily subscribers compared to non-subscribers; $t(253)=2.42, p < 0.02$ for immediate subscribers compared to non-subscribers). Note, however, that response times are not significantly different. In particular, immediate subscriptions do not necessarily lead to faster median response times.

Usage Survey

To understand how specifications are reviewed, awareness of comments, and satisfaction with the default Web Discussions email notifications, we surveyed a subset of current Web Discussions users. We contacted approximately 250 people and received 98 responses from testers (38%), PMs (29%), developers (16%), and others (17%) including documentation and usability specialists.

Reviewing Specifications

The primary methods respondents reported using to comment on specs are email (84%), Web Discussions (81%), face to face at spec review meetings (80%) and face to face with spec authors (63%). As Table 2 shows, participants are most likely to use Web Discussions for comments if they do not need a response before the next specification review meeting (there are usually two such meetings per spec) or for a couple of days.

Awareness

Survey respondents agreed it was important to stay aware of comments on specs for features they are responsible for and those they are interested in. (Median response was "Agree." All questions were on a 5-point scale from "Strongly Disagree" and "Strongly Agree.") When asked if it was easy to stay aware of comments for specs they were working on, the median response was "Strongly Agree." In contrast, the ease of following comments on specs they were interested in received a median response of "Neutral."

Table 2. Methods used to comment when timely responses are needed (98 respondents).

	Immediate Response	Within a few hours	Within a day or two	Until next review	Total
Face-to-face	53	8	1		62
Use email	22	73	43	13	151
Use Web Discussion	5	10	45	55	115
At spec review	6		1	21	28
Other	12	7	8	9	36

Existing Notifications

Eighty-four respondents (86%) had used Web Discussions for spec reviews. The median was "Agree" that using Web Discussions for spec reviews works well. Forty-three respondents had subscribed to the existing email notifications. They typically subscribe to notifications for specs they are working on but did not author (84%), and they are less likely to subscribe to specs they author (44%) or review (40%). Satisfaction with email notifications was quite low: The median was "Disagree" for "I am satisfied with the current email notifications for Web Discussions."

We asked respondents to comment on what they liked and disliked about email notifications. Most positive comments stressed that notifications saved them from repeatedly checking the document for changes and a few commented that they appreciated choosing when to be notified. Many negative comments focused on the lack of helpful content in the notifications and on email overload.

NOTIFICATION DESIGN CONSIDERATIONS

The literature and our study of Web Discussions indicate that an annotation notification mechanism should:

- Keep users aware of annotation activity around documents they are interested in.
- Provide users the right amount and type of information at the right time.
- Support a lightweight, easily customized subscription mechanism.
- Provide means for users to easily follow-up on annotation activity.
- Indicate who will be notified of comments.

Given these criteria, there are significant tradeoffs in designing an effective notification experience. For instance, we must balance keeping people adequately informed against overwhelming them. Notifying someone every time an annotation is made may be too often. However, in some cases, waiting an entire day to notify a user of activity on a document may be undesirable. It should be easy to subscribe to notifications, but reasonable choices for notification frequency must be provided.

We must also balance the information the notification provides against the user's level of interest. Notifications should by default provide enough information to be helpful,

but different users may prefer varying levels of detail; this too should be easily configured.

Finally, privacy concerns must be balanced against the convenience of awareness. If users cannot see who will receive notifications, they may send email that duplicates automatic notifications [4].

NOTIFICATION ENHANCEMENTS

Inspired by the design considerations we implemented enhancements to Web Discussions notifications and performed a field study of their use. We explored the design tradeoffs using two methods: improving existing email notifications and implementing notifications using peripheral awareness.

Detailed Email Notification

To provide more information in notification messages we implemented an email notification service for Web Discussions. As shown in Figure 2, our notifications include the content of new annotations and indicate when an annotation is a reply to an existing annotation. During the field study described in the next section we added a direct hyperlink from a comment in email to its location in the document to allow users to easily follow-up on annotation activity.

Using a simple web form users select to have our email notifications about new annotations on a document delivered immediately, daily or weekly. In addition to these standard options, users signed up for daily or weekly emails can ask for immediate notification messages to be sent for replies to their annotations. To reduce the amount of notification mail a user receives, users are not notified about annotations they create.

Peripheral Notifications using Sideshow

Email is commonly used for notification; however it seems heavyweight for maintaining continuous awareness. Constantly tracking the annotations on a document could result in many messages. To explore another channel for notifications we implemented notifications using the Sideshow [5] peripheral awareness system.

The Sideshow system uses a small amount of screen real estate for its peripheral awareness sidebar. The Sideshow sidebar sits on the side of the screen and contains items

The following change(s) happened to the document <http://server/Notify.htm>

Event: Discussion items were inserted or modified in the document.

By: colinb

Time: 9/12/2001 3:20:24 PM

[Click here to stop receiving this notification.](#)

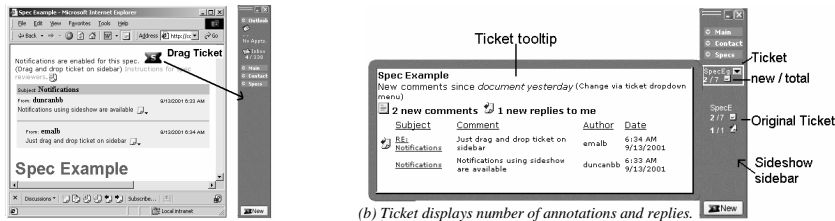
This is an automatic notification. [More information...](#)
Click here to [update your notification settings.](#)

The changes that just occurred are:
On <http://server/Notify.htm>

colinb added a reply to a comment by duncanbb on 9/12/2001 3:20 PM
RE: test annotation
This is the text of an example annotation.

[Click to update your notification settings.](#)

Figure 2. On the left, Web Discussions current e-mail notifications. On the right, our enhanced e-mail notifications.



(a) Subscribe by dragging ticket to Sideshow

Figure 3. Peripheral notifications using Sideshow.

called *tickets*. Each ticket displays information from a particular source. Examples of Sideshow tickets include an inbox ticket that displays information about your email inbox, and a “traffic ticket” that monitors traffic congestion from municipal traffic cameras. The tickets displayed can be customized by the user and Sideshow supports designing new tickets.

For annotation notifications we implemented a Web Discussions Sideshow ticket that displays general information about the number and contents of annotations on a particular document. Figure 3 (a) shows a document with a Sideshow ticket on it. To subscribe to annotation notifications, a user simply drags the ticket from the document and drops it on their sidebar. Thereafter they can see current information about annotations made on the document by glancing at the ticket on the sidebar.

The ticket, shown in Figure 3 (b), displays the total number of annotations and annotations that are new today. By default, annotations made on the same day are considered “new,” but the user can easily customize this to either annotations made since the current time or all annotations made on the document. The original ticket used in the first half of our field study had a second line that displayed the total number of replies to comments made by the user running Sideshow, and the number of new replies.

When the user mouses over a ticket, the tooltip window shows more detail about new annotations, including the author, creation time, and contents. In the second half of our field study the tooltip also included direct hyperlinks that opened the document directly to an annotation.

FIELD STUDY OF NOTIFICATION ENHANCEMENTS

To study the effectiveness of our enhanced notifications, we deployed them among a small subset of users in the product group for use in their specification review process.

Study Methodology

In mid-August we approached program managers (PMs) in three groups using Web Discussions and asked them to identify specification documents that would be reviewed soon.

Specs are reviewed over a period of a few weeks to a few months by PMs, developers, testers and others including

documentation and usability specialists. For each spec at least two meetings are also scheduled where people meet face-to-face to discuss issues with the spec and go over the Web Discussions comments made on it.

We added Sideshow tickets to specs identified by the PMs and encouraged people reviewing the documents to try our detailed notifications. We also contacted everyone who had previously signed up for the default Web Discussions notifications and asked them to try our notifications.

Integrating our notification mechanisms did not alter the specification review process for the teams that tried it. They continued to use Web Discussions for commenting on their specs, and could still elect to use the default Web Discussions notifications, but they had the added option of using our more detailed notifications instead.

Before trying our notifications, participants filled out the survey of current usage discussed previously. Some users filled out the current usage survey but did not subscribe to our enhanced notifications. In general these users either did not need notifications to stay aware of specs or currently had no specs they needed to stay aware of.

On September 10th we surveyed current users for feedback and interviewed six users in depth. At this time, 39 people were subscribed to our enhanced notifications: 22 of them were using Sideshow tickets, 10 were subscribed to our email notifications, and 7 people were using both. This feedback survey received 22 responses, primarily from PMs (41%), and testers (36%).

We then introduced some improvements based on the feedback and recruited additional participants. On November 26th we again surveyed current users and conducted two additional interviews. By this point, 90 people had used our notifications, 60 had Sideshow tickets, 18 were subscribed to email and 12 were using both. The final survey received 31 responses from PMs (39%), developers (23%), testers (19%), and others (19%). 12 people answered both the Sept. and Nov. surveys.

General Experience

188 people made 4,221 annotations on 98 documents involved our field study. 57 (30%) of the 188 people adopted our notifications exclusively, 30 (16%) adopted

Web Discussions notifications exclusively, and 16 (9%) used both systems. 85 (45%) annotators did not subscribe to any notifications. Each annotator created an average of 22.3 annotations on an average of 2.4 documents, and each document had on average 43 annotations.

Surveys and interview data indicate field study participants were positive about our notifications. Participants particularly appreciated the fact that our enhanced notifications allowed them to stay aware of annotation activity without opening a spec. One participant said “[Sideshow] kept me up to date about what discussions were occurring about my specs,” while another told us “[the email notifications] keep me up to date.”

The two primary uses of our notifications during spec review were active monitoring of annotations and more casual tracking of annotation activity. Active monitoring was primarily done using Sideshow tickets. One program manager we interviewed watched until the ticket showed five or six comments, then dealt with them all at once.

Participants also used both Sideshow and email to passively track annotations. One manager used Sideshow to notice when not enough comments were being made (previously he did the same tracking by opening the spec). Another person kept the email notifications around until he had time to visit the spec.

Survey respondents felt using our notifications affected their behavior. On both surveys, when asked about their awareness of online comments on specs where they had our notifications, the median response was that they were “more” aware. When asked about how fast they responded to other comments, the median response was that they responded “faster.”

Respondents felt there was no change in the amount of online discussion, nor in the number of comments they made, or the speed with which other people responded to comments on specs with our enhanced notifications. This is perhaps understandable since not everyone involved with a particular spec subscribed to our notifications.

Respondents also answered more specific questions for the enhanced notifications types that they tried.

Notifications Using Sideshow Tickets

Sixteen of the respondents (73%) on the Sept. survey and twenty of the respondents (65%) on the Nov. survey had used Sideshow tickets, typically for 3-5 specs.

Ease of Use

On both surveys, respondents’ median response was to “Agree” that Sideshow tickets were easy to install and use. (All questions were on a 5 pt. scale from “Strongly Disagree” to “Strongly Agree.”) Respondents also “Agreed” that the tickets provided enough information about the comments on the specs. Based on interview data, subscribing to notifications using Sideshow was very easy.

The ability to customize the ticket to change which comments were considered “new” and shown in the ticket

Table 3. Most valuable information in the ticket tooltips.

Information on Ticket Tooltip	1 st	2 nd	3 rd	Total
Content of new comments	5	4	2	11
Num. of comments & replies to me	6	2	2	10
Subject line of new comments	5	4		9
Hyperlinks to open spec to comment	2	3	4	9
Author of new comments		2	7	9
Date of comment		2	1	3
Context from spec around comment*	1	1		2
Reply to me icon			1	1

* Not currently implemented

tooltip was used by some participants. Half the Nov. survey respondents (10) had customized a ticket’s settings to change which comments were considered “new” and shown in the ticket tooltip. (Note, this question was not asked on the Sept. survey.) In interviews participants also discussed changing the “new” setting, and the preferred setting seems related to the rate of comments on the spec.

Design Improvements

The interviews and Sept. survey data identified several ways to improve the tickets. In order to facilitate tracking a large number of specs, participants thought tickets needed to be much smaller. They felt the title and the number of new annotations were most important to display on the ticket and “Agreed” that hyperlinks that opened the spec directly to a comment would be useful.

We introduced the smaller version of the ticket shown in Figure 3 (b) in mid-Oct. and also added hyperlinks to the comments in the tooltips. On the Nov. survey 14 respondents (70%) preferred the second version of the ticket. We also asked respondents to rate the three most valuable pieces of information in the tooltip. As shown in Table 3, the new hyperlinks were quite popular.

For the future, interview data suggests other design improvements to try including: a ticket that summarizes several specifications, filtering comments in the tooltips, and visual changes to a ticket when new comments occur.

Email Notifications

Nine of the respondents (40%) on the Sept. survey and eleven of the respondents (35%) on the Nov. survey were subscribed to email notifications. On both surveys, participants signed up for email notifications “Agreed” that enhanced email notifications were useful and they provided enough information about new comments.

Subscriptions

30 people made 131 subscriptions to our enhanced email notifications on 122 different documents. Similar to the usage of the default Web Discussion notifications, there are more subscriptions (86, 65%) for daily notifications compared to immediate (44, 34%) and weekly (1, 1%) notifications. We found it somewhat surprising that only

Table 4. Most valuable information in email.

Information in Email	1 st	2 nd	3 rd	Total
Content of new comments	7	1	1	9
Author of the comment	2	2	3	7
Hyperlinks to open spec to comment	1	4		5
Context from spec around comment [*]		2	2	4
Whether comment was reply			3	3
Subject line of the comment		1	1	2

^{*} Not currently implemented

nine of the daily subscriptions (10%) asked for immediate emails for replies to comments made by the subscriber.

Design Improvements

On the Sept. survey participants "Agreed" that direct hyperlinks from the comment to its location in the spec would also be useful for email notifications. We added hyperlinks to emails at the same time we included them in the Sideshow tooltips. Table 4 outlines ratings by participants on the Nov. survey of the three most valuable pieces of information in the email and highlights the value respondents placed on the hyperlinks.

Surveys and interviews indicated that including context information might be more important in email than in Sideshow. Other design suggestions included a clearer visual distinction between replies and new annotations, and including the text of annotations that were replied to.

DISCUSSION

Our enhanced notifications were generally successful and met many of our design criteria. Field study participants reported that both Sideshow and our detailed email notifications were useful, particularly in contrast to the dissatisfaction with default Web Discussions email notifications found by the initial usage survey. Our experience points to several critical issues to consider in designing other annotation notification systems.

Different Uses of Notifications

Annotation notification mechanisms generally need to be flexible enough to support both active monitoring and more casual tracking, as well as other uses. We found providing notification via different communication channels, with Sideshow and email, critical so that users can choose the delivery mechanism that best fits their needs. Providing detailed information in the notifications is also helpful, allowing users who are actively monitoring or passively tracking to make informed decisions about the importance of an annotation that has been made.

Roles and Notifications

The number of specs a person is responsible for and their job role affects the value and usage of notifications. More study is needed, but our data suggest that notifications become more useful as the number of specs a user is responsible for increases. People responsible for many specs, such as managers and tech writers, assessed notifications as being more valuable. In particular,

notifications provide a way to monitor activity on the spec and decide when to revisit.

The interview and survey data also suggest very different opinions about notifications among authors of specifications. Some authors felt they already checked on their own specifications frequently enough and did not need notifications, while others appreciated the notifications as a way to track comments.

Notification may generally be more valuable for tracking specs that cover related features or that come from other groups. Several users wanted to read and respond to more related specs. Perhaps if notifications are more informative, users will subscribe to them to track related specs.

Cultural Considerations

Prevailing group culture may affect notification usage as well. Based on the initial usage study and interviews, groups use several different methods to communicate feedback on specifications. The value of notifications may be heavily influenced by the amount a group relies on annotations for feedback compared to other options such as email or face-to-face meetings.

In addition, Cadiz et al. found that notification email may be redundant anyway, since some users tended to send email directly when timely notification of a comment was important [4]. Providing meta awareness of who is subscribed to notifications may increase the value of automatic notifications and is an area for future research.

Configuration and Subscription

Due to the range in interest levels and rate of comments made on specs, easy configuration of notifications is critical. People generally agreed about the content of our notification messages, but opinions varied when it came to email notification frequency and Sideshow ticket settings.

Our experience reinforced the importance of making subscribing convenient. One advantage of a Sideshow ticket was the ease of dragging it from the spec document over to the Sideshow sidebar. For email subscriptions the participants had to go to a separate web page. This may be why fewer people tried our email notifications.

Although default Web Discussions email subscriptions can be done directly from a spec, they still require user action. Users may favor an automated approach in which they are subscribed to daily notifications when they first comment on a document. Opt-out mechanisms can be dangerous, but if notifications contain enough information and are easy to unsubscribe or filter, this could be a popular feature.

"Replies to me"

We initially thought informing people of replies to their annotations would be particularly valuable. However, it appears Web Discussions are used less as a place for quick conversation and more for issues to be tracked. Knowing about replies to your comments may be interesting, but less important to know immediately.

That said, on other tasks reply notification may be more important. Some users in our field study did sign up for our

immediate email for replies to their comments, so supporting this capability does seem worthwhile. Furthermore wider use of notifications may lead to quicker response times and could make features like specialized reply notifications more valuable.

Notifications about document changes

Our notification enhancements focused on making people aware of annotations made using Web Discussions. Many people said that they wanted similar detailed information about updates to the spec document. The existing notification mechanism can notify people of document changes, but the notification messages do not contain much information. In interviews users indicated that knowing that the spec changed and perhaps some measure of the amount of change (e.g., small, medium, major) would help. As a first step we will integrate the time of the most recent file content change into our annotation notifications.

CONCLUDING REMARKS

An effective and useful notification mechanism is an important part of a shared document annotation system. A study of a commercial annotation system found that it failed to meet user needs. An enhanced system shows promise based on the field study described in this paper. In particular, providing more information about new annotations, supporting multiple communication channels through which notifications could be received, and allowing customization of notification messages were popular. Overall awareness of annotation activity on specs increased with our enhancements.

With the advent of more powerful portable computers, annotation is an active focus of research and development. We have identified several important considerations for designers of annotation notification systems. Users want notifications to provide as much detail as possible while requiring minimal effort to subscribe to or monitor. Within the context of one task users have different preferences for notification settings. The usage of configuration options highlights the importance of making customization easy. Multiple channels to deliver notifications proved valuable to support different styles of use.

There remains much to do. Providing more contextual information in email notifications tops the list, and the issue of meta-awareness remains unexplored. As we gather more data, we can build a more complete picture of the use and potential of annotation notifications.

ACKNOWLEDGEMENTS

We are grateful to the participants in our field study. We also thank JJ Cadiz and the reviewers for their comments.

REFERENCES

- [1] Appelt, W. What groupware functionality do users really use? Analysis of the usage of the BSCW system. *Proc. 9th Euromicro Workshop on PDP*. <http://bscw.gmd.de/Papers/PDP2001/PDP2001.pdf>

- [2] Appelt, W. WWW Based Collaboration with the BSCW System. *Proc. SOFSEM'99*, Springer Lecture Notes in Computer Science 1725, 66-78; <http://bscw.gmd.de/Papers/SOFSEM99/sofsem.pdf>
- [3] Baecker, R. Nastos, D. Posner, I. and Mawby, K. The User-centered Iterative Design of Collaborative Writing Software. *Proc. INTERCHI 93*, 399-405.
- [4] Cadiz, J. Gupta, A. and Grudin, J. Using Web Annotations for Asynchronous Collaboration Around Documents. *Proc. CSCW 2000*, 309-318.
- [5] Cadiz, J. Venolia, G. Jancke, G. Gupta, A., 2001. Sideshow: Providing Peripheral Awareness of People and Information, Microsoft Technical Report 2001-83. http://research.microsoft.com/scripts/pubs/view.asp?T_R_ID=MSR-TR-2001-83.
- [6] Crit.org. <http://www.crit.org>
- [7] Dourish P. and Bellotti V. Awareness and Coordination in Shared Workspaces. *Proc CSCW '92*, 107-114.
- [8] Fuchs, L. AREA: A Cross-Application Notification Service for Groupware. *Proc. ECSCW 99*, 61-80.
- [9] Gutwin, C. Roseman, M. and Greenberg, S. A Usability Study of Awareness Widgets in a Shared Workspace Groupware System. *Proc. CSCW 96*, 258-267.
- [10] Intraspect. Enterprise Collaboration Management with Intraspect, <http://www.intraspect.com/>
- [11] Koch T. and Appelt W. Beyond Web Technology-Lessons Learnt from BSCW. *Proc. 1998 IEEE WEI ICE Workshop*, <http://bscw.gmd.de/Papers/wetice98/index.html>
- [12] Leland, M., Fish, R., and Kraut, R. Collaborative Document Production Using Quilt. *Proc. CSCW 88*, 206-215.
- [13] Livelink. Functional Assessment of Open Text Livelink. <http://www.opentext.com/livelink/>
- [14] Lotus QuickPlace Release 2.0 Reviewer's Guide. <http://www.lotus.com/home.nsf/welcome/quickplace>
- [15] Microsoft Office 2000 Web Discussions, <http://office.microsoft.com/assistance/2000/wWebDiscussions.aspx>
- [16] Neuwirth, C. Kaufer, D. Chandhok, R. and Morris, J. Issues in the Design of Computer Support for Co-authoring and Commenting. *Proc. CSCW 90*, 183-195.
- [17] Ovsiannikov, I., Arbib, M., and McNeill, T. Annotation Technology, *Int. J. Human Computer Studies*, (1999) 50, 329-362.
- [18] Röscheisen, M. Mogensen, C. and Winograd, T. Shared Web Annotations as a Platform for Third-Party Value-Added, Information Providers: Architecture, Protocols, and Usage Examples, Technical Report CSDTR/DLTR (1997), Stanford University.