

Notification for Shared Annotation of Digital Documents

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ABSTRACT

Notification and shared annotation go hand-in-hand. It is widely recognized that notification of activity in a shared document annotation system helps support awareness and improve asynchronous collaboration. But few studies have examined user needs, and there has been little exploration of design tradeoffs. We examined the large-scale use of notifications in a commercial system, and found it lacking. We designed and deployed enhancements to the system, and 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 could be received, and allowing customization of notification messages were particularly important. Overall awareness of annotation activity on specs increased with our enhancements.

Keywords

Notification, annotation, annotation system design

1 INTRODUCTION

Shared annotations on digital documents are an attractive means of asynchronous collaboration: They reduce the writing required by allowing comments in-context; they help readers by displaying comments along with the original document. As an effective means of communication, however, they suffer from a major flaw: Interaction is primarily between person and document, not person and person. As a result, communicating ideas is often slow and cumbersome, and people must continually revisit a document to see the latest comments.

One way to alleviate this problem is to integrate a notification mechanism into the 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 different systems (e.g. [2] [5] [10] [12] [13] [15]) have used this approach with varying degrees of success. E-mail notifications are common in commercial systems.

While notification mechanisms in shared annotations systems are common, there have been few studies of user needs and little exploration of the design tradeoffs. This paper's primary contribution is to take those steps. First, we report on the current usage of notifications in Microsoft Office Web Discussions, a shared annotation system that includes a closely-integrated notifications mechanism. Informed by this study, we designed and deployed improvements to the notification mechanism that include

more detailed e-mail notifications and notifications using peripheral awareness.

User reaction to our enhanced notifications was positive and from our experience we have identified several important considerations for designers of annotation notification systems. Users wanted notifications to provide as much detail as possible while requiring the least amount of effort to subscribe or monitor notifications. Within the context of the same task we found users had very different preferences for notification settings. The configuration options in our notifications were widely used, highlighting the importance of making notifications easy to customize. We also found providing notifications using multiple channels valuable to support different styles of use.

In the next section, we discuss related work. Section 3 outlines criteria for an effective annotation notification mechanism. In Section 4, we discuss the current use of notifications in a commercial annotation system. Sections 5 and 6 outline our notification enhancements for the system and a field study of their use. Section 7 discusses implications of our work for the design of annotation notification mechanisms.

2 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.

2.1 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.

2.1.1 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. The second level enlarges the icons, the third level scrolls messages at the bottom of the main window, and the fourth level events are displayed in a dialog box. 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 visits, 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.

2.1.2 Subscription based

Many document collaboration and annotation systems that provide notifications (e.g. Quilt [12], Crit.org [5], 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 e-mail. 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 e-mail notifications directly to other people. We study the Web Discussions [15] notification mechanism in more detail in this paper.

2.1.3 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 focused 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.

2.2 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 e-mail 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 is meant to redress this imbalance.

3 EFFECTIVE NOTIFICATIONS

A well-designed annotation notification mechanism must:

- Keep users aware of annotation activity around documents they are interested in.
- Send users the right amount and type of information at the right time.
- Support a lightweight subscription mechanism and be easily customizable.
- Operate via familiar and convenient channels of communication.
- Provide means for users to easily follow-up on annotation activity.
- Provide meta awareness of who is subscribed for notification on a document.
- Provide means for *annotators* to change notification frequency or modify who will be notified.

Given these criteria, there are significant tradeoffs in designing an effective notification user experience. For instance, we must balance keeping people adequately informed against overwhelming them. It should be easy to subscribe to notifications. However, users must be given useful choices for the frequency with which they receive notifications. Notifying users every time an annotation is made may be too fine-grained; however, waiting to notify a user of all activity on a document over an entire day may be too coarse.

We must also balance the level of detail included in a notification message against the confusion it may cause a user. We could, for instance, decide which notifications to send to which user based on the nature of the annotation activity, the user's level of interest, and their role (e.g. their job, or whether they are doc author, or another annotator). This may reduce the confusion they experience when viewing notifications, but it may increase the complexity of subscribing to notifications in the first place.

Finally, privacy and security concerns must be balanced against the degree of flexibility that the notification mechanism affords individual subscribers and annotators. If users cannot see who is subscribed for notifications they may send e-mail about important changes and duplicate automatic notifications. If users can subscribe to any document, they may elect to receive notifications for documents for which they do not have read access.

4 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, and we focused on their utilization of the default notification mechanism built into the system. The product group uses Web Discussions to comment on software feature specification documents, or “specs.” We also surveyed a subset of people to assess their experience with the default notification mechanism.

4.1 Web Discussions

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

4.1.1 Notification Mechanism

Web Discussions includes a simple default notification mechanism. By clicking on the “subscribe” button in the Web Discussions toolbar users can request to be sent e-mail

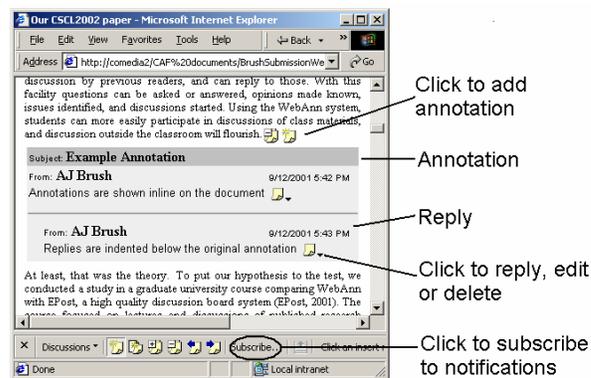


Figure 1: A web page annotated with Office Web Discussions.

when annotations on the document are made or modified. Users can subscribe to have e-mails sent for any change or to receive a summary e-mail daily or weekly. An example of the change notification e-mail is shown in Figure 2.

Cadiz et al [4] found several significant drawbacks to this mechanism. In particular it does not meet many of our criteria for effective notifications. For instance, the current system does not provide information about what annotations have been added or make it easy to follow-up on the annotation activity. 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 provides no meta awareness to annotators of who is subscribed to a document.

4.2 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 e-mail notification of Web Discussion events (adding comments, deleting comments, modifying comments, “resolving” a comment, and so on).

4.2.1 Users and Notifications

With respect to notifications Web Discussion users fall into three groups: 348 users who made annotations but did not

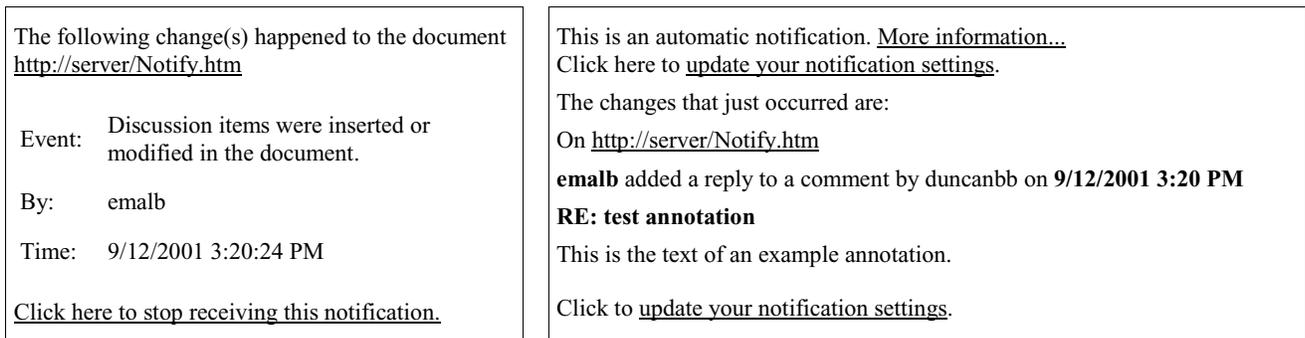


Figure 2: On the left, Web Discussions current e-mail notifications. On the right, our enhanced e-mail notifications.

Subscription	Replies	ART
immediate	23.4	202
daily	24.6	228
none	8.8	256

Table 1: Average number of replies and average response time (ART, in hours) for different classes of subscribers across all replies.

subscribe to notifications at all, 118 users who made annotations and subscribed, and 48 users that subscribed but did not make annotations. Note that the majority (75%) are not subscribed for 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.

There were 48 users subscribed for notifications that did not make any annotation. Each of these users had an average of 4.94 subscriptions, and in total this group held 237 subscriptions to 200 documents. Daily subscriptions were again the most popular, comprising 138 of the 237 subscriptions (58%) with 98 (41%) immediate subscriptions and 1 weekly subscription.

4.2.1 Responsiveness

In general, as Table 1 illustrates, users who subscribed in any capacity made significantly more replies than those who did not ($t(124)=2.764$, $p=0.007$ for daily subscribers compared to non-subscribers; $t(121)=2.859$, $p=0.005$ for immediate subscribers compared to non-subscribers). Users who subscribed to more frequent notifications had shorter average response times, although the differences are not significant. Note that all average response times are longer than 8 days. Only one person of the 132 who made replies subscribed to weekly notification, so we did not include weekly subscriptions in our analysis.

4.3 Usage Survey

Our survey of current usage asked general questions about reviewing specifications and awareness of comments using the default Web Discussions notification mechanism. We also asked specific questions about satisfaction with Web Discussions and its e-mail notifications. We received 69 responses to the initial survey.

4.3.1 Reviewing Specifications

The primary methods respondents use to comment on specs are Web Discussions (86%), E-mail (83%), at the spec meeting (81%) and in face to face discussions with the spec author (62%) (they could mark multiple methods). As Table 2 shows, participants were mostly likely to use Web

	Immediate Response	Within a few hours	Within a day or two	Until next review
Face-to-face	39	5		
Use e-mail	16	51	25	8
Use Web Discussion	4	8	39	41
At spec review	6			15
Other	4	5	5	5

Table 2: The method used to make a comment when survey respondents need a response within a certain amount of time. Number of respondents is sixty-nine.

Discussions for comments if they do not need a response until the next specification review meeting (two total per spec) or for a couple of days. It appears respondents are aware of the long average response times (8 days) we found when analyzing recent usage of Web Discussions.

4.3.2 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 4, "Agree") When asked if it was easy to stay aware of comments for specs they were working on the median response was also 4 ("Agree"). However, the ease of staying aware of comments on specs they were interested in received a median response of 3 ("Neutral"). All questions were on a 5 pt Likert scale where 1 was "Strongly Disagree" and 5 was "Strongly Agree."

4.3.3 Existing Notifications

Sixty of the respondents (87%) had used Web Discussions for spec reviews. The median response was 4 ("Agree") that using Web Discussions for spec reviews works well. Thirty-one of the respondents had subscribed to the existing e-mail notifications.

They typically subscribe to notifications for specs they are working on but did not author (50%), and they are less likely to subscribe to specs they author (32%) or review (22%) (they could mark multiple).

The satisfaction with e-mail notifications was quite low. The median response was 2 ("Disagree") for "I am satisfied with the current e-mail notifications for Web Discussions."

We asked respondents to comment on what they liked and disliked about e-mail notifications. The majority of the 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. The negative comments focused on the vague notifications and overload of e-mail. Table 3 has examples of the participant comments.

Like about Notifications	Dislike about Notifications
<p>“Saves me having to monitor manually for spec changes”</p> <p>“It at least tells you that something is happening via email.”</p> <p>“Have the option to get notification immediately, daily, and weekly “</p>	<p>“No content at all but telling you something is changed. “</p> <p>“lack of helpful content”</p> <p>“I generally get too much email; the information isn't useful to me. “</p>

Table 3: Examples of positive and negatives comments about e-mail notifications from the initial survey.

5 NOTIFICATIONS ENHANCEMENTS

Following our study of current usage of the Web Discussions notification mechanism, we implemented enhancements to it so that it would provide more detailed notifications and would be less overwhelming to users. We experimented with enhancing notifications in two ways: improving existing e-mail notifications, and implementing notifications using peripheral awareness.

5.1 Detailed E-mail Notification

We implemented an e-mail notification service for Web Discussions that includes additional information in the notification messages. Similar to the default Web Discussions notification system, users subscribe on a per document basis. However, as shown in Figure 2, our notifications include the content of new annotations and information about whether the annotation is a reply to an existing annotation.

Using a simple web form users can select to have our e-mail notifications about new annotations on the document delivered immediately, daily or weekly. In addition to these standard options, users signed up for daily or weekly e-mails 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 author.

5.2 Peripheral Notifications using Sideshow

E-mail 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 called *tickets*. Each ticket displays information from a particular source. Examples of Sideshow tickets include an inbox ticket that displays information about your e-mail inbox, a calendar ticket that provides information about your next appointment, and a “traffic ticket” that monitors traffic congestion from municipal traffic cameras. The

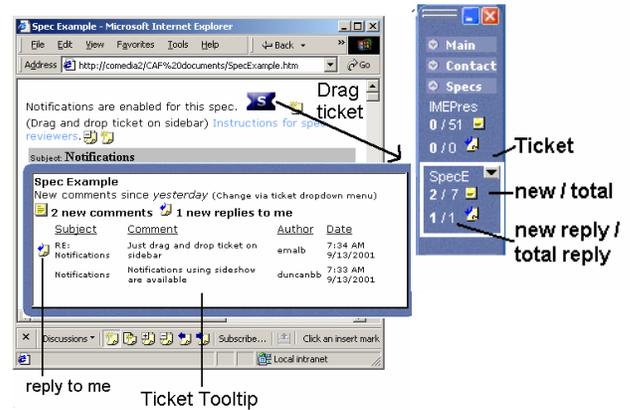


Figure 3: Peripheral Notifications using a Sideshow. The ticket displays the number of annotations and replies. A tooltip window shows details for new annotations when the user mouses over the ticket.

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 shows a document with a sideshow ticket on it. To subscribe to notifications of annotation activity, 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 displays the total number of annotations, and annotations that are new today, on the first line. The second line displays the total number of replies to comments made by the user running Sideshow, and how many of those replies were made today. When the user mouses over the ticket, the tooltip window shows more detail about new annotations, including the author, creation time, and contents. By default, annotations made on the same day are considered “new,” but the user can easily change this to either annotations made since the current time or all annotations made on the document.

6 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.

6.1 Study Methodology

The field study began on August 16th 2001. We initially approached program managers in two groups using Web Discussions and asked them to identify specification documents that would be reviewed soon.

Program managers (PMs) are responsible for writing software feature specification documents (or “specs”) that are subsequently reviewed by the developers and testers who will implement and test the features. Others, including documentation and usability specialists, also participate in the review process. Specs are reviewed over a period of a

few weeks to a few months. For each spec at least two meetings are also scheduled for each spec, 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, they 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.

Groups continue to use our notifications and data collection is ongoing. The specs currently subscribed to have had a wide range of activity, ranging from no comments at all to 19 or more in a day. We interviewed 6 users in more depth on Sept. 7th and 10th. At that point, 39 people were subscribed to our enhanced notifications: 22 of them were using Sideshow tickets, 10 were subscribed to our e-mail notifications, and 7 people were using both. We surveyed current users for feedback and suggestions and received 22 responses.

6.2 General Experience

Surveys and interview data indicate participants were very 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 said "*I can see the real-time information on opened web discussions,*" and a third told us "*[the e-mail 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 watched until the ticket showed five or six comments, then dealt with them all at once.

Participants also used both Sideshow and e-mail 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 e-mail notifications around until he had time to visit the spec.

Survey respondents felt using our notifications affected their behavior. When asked about their awareness level 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, 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. Responses for all specific questions were on a 5 pt. Likert scale where 1 was "Strongly Disagree" and 5 was "Strongly Agree."

6.3 Notifications Using Sideshow Tickets

Sixteen of the survey respondents used Sideshow tickets. Eight tried them for 3-5 specifications, four for two specs and four for one spec.

6.3.1 Ease of Use

Respondents' median response was to "Agree" that Sideshow tickets were easy to install and use. 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.

Sideshow tickets also appear easy to customize. In interviews users discussed changing the setting for which annotations were considered new and had their details displayed in the ticket tooltip. The preferred "new" settings seemed related to the rate of comments on the spec: If there were few comments on a spec, users set "new" to encompass all comments; while for specs with many comments, "new" was reset to the current time each time the person read comments. Other users kept the default setting, where annotations made on the same day were shown as "new."

6.3.2 Design Improvements

The interview and survey data identified several ways to improve the tickets. In order to facilitate tracking a large number of specs, for instance, participants thought tickets needed to be much smaller. They told us that the title and number of new annotations are the most valuable information to display on the ticket, and all other information can be moved to the tooltip.

They also agreed that adding hyperlinks so that clicking on a comment would open the spec directly to it would be useful. When asked if additional contextual information should be included for each comment (such as an excerpt from the document where the comment was made) participants had no strong feelings. Perhaps users felt that with a link directly from the tooltip to the comment in the spec the context would be unnecessary.

Subscription Type	Subscriptions	Participants
Immediate	15 (34%)	7 (41%)
Daily	28 (64%)	9 (53%)
Weekly	1 (2%)	1 (6%)
Total	44	17 (unique)

Table 4: E-mail subscriptions. Participants signed up for only one type of subscription, either immediate, daily or weekly

6.4 E-mail Notifications

17 people have made 44 subscriptions to our enhanced e-mail notifications on 41 different documents so far. Table 4 shows that the majority of the subscriptions are for daily summary e-mail. This is similar to the usage of the default Web Discussions notification mechanism. 4 daily subscribers to our e-mail notifications also signed up for immediate e-mail of replies to their comments for all their subscriptions.

6.4.1 Design Improvements

9 of the 22 people who took the survey were signed up for our e-mail notifications. Respondents appreciated the detailed information in the e-mails, and most agreed that our enhanced e-mail notifications were useful.

Respondents also thought direct hyperlinks from the comment to its location in the spec would be useful for email notifications too. We are currently working on providing these hyperlinks for e-mail and on the Sideshow tooltip. However, integrating this feature with Web Discussions may require installation of additional software by the user, and this could limit usability and adoption.

Unlike the Sideshow feedback, surveys and interviews indicated that including context information may be more important in e-mail. Other suggestions included making a clearer visual distinction between replies and new annotations, and including the text of annotations that were being replied to.

7 DISCUSSION

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

7.1 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. Providing notification via different communication channels, for instance via Sideshow and email, is 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.

7.2 Roles and Notifications

The number of specs that 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 rises. 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.

For users responsible for a limited number of specs, however, the value of notifications was marginal: They either subscribed to notifications to track casually or checked on a spec directly every couple of days (and ignored notifications altogether).

For all users, notification may be more valuable for tracking specs that deal with related features or come from other groups. Several wanted to read and follow-up on more related specifications. Perhaps as notifications contain more information users will subscribe to them to track related specs.

7.3 Cultural Considerations

Prevailing group culture may affect notification usage as well. For instance, our usage study of the default Web Discussions notifications found that the majority (75%) of annotators did not subscribe to notifications, and our usage survey results indicate that the default Web Discussions notification mechanism did not meet user needs. Although users appear satisfied with our enhanced notifications, if people have had a bad experience with the default Web Discussions notifications it may be harder to get them to adopt our improvements.

In addition, Cadiz et al found that notification email may be redundant anyway, since users tended to send email directly when timely notification of a comment was important [4]. This could further slow adoption of more automatic notifications mechanisms.

7.4 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 e-mail notification frequency and Sideshow ticket settings.

Subscribing to notifications must also be convenient and simple. One advantage of a Sideshow ticket was the ease of dragging it from the spec document over to the Sideshow sidebar. For our e-mail subscriptions the participants had to go to a separate web page. This may be why fewer people tried our enhanced e-mail notifications.

Although the default Web Discussions e-mail 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.

7.5 "Replies to me"

We initially thought informing people of replies to their annotations would be particularly valuable. However, based both on the usage analysis, initial usage survey, and interviews, 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 e-mail for replies to their comments, so supporting this capability does seem worthwhile. And wider use of notifications may lead to quicker response times, and could make features like specialized reply notifications more valuable.

7.6 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.

8 CONCLUDING REMARKS

An effective and useful notification mechanism is an important part of a shared document annotation system. Very few if any studies have explored user needs in this regard, and this paper attempts to fill this gap.

We explored the current usage of notifications in a commercial annotation system, and found that it does not meet user needs. We designed and deployed enhancements to the system, and found through a field study that they address some user needs more effectively. 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.

There remains much to do. Tying notifications more directly to comments in a document and providing more contextual information in e-mail notifications top the list, and the issue of meta-awareness remains unexplored. As we gather more data, we will be able to build an even more complete picture of the use and potential of annotation notifications.

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