The CloudBoard Research Platform: an interactive whiteboard for corporate users

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ABSTRACT

Over one million interactive whiteboards (IWBs) are sold annually worldwide, predominantly for classroom use with few sales for corporate use. Unmet needs for IWB corporate use were investigated and the CloudBoard Research Platform (CBRP) was developed to investigate and test technology for meeting these needs. The CBRP supports audio conferencing with shared remote drawing activity, casual capture of whiteboard activity for long-term storage and retrieval, use of standard formats such as PDF for easy import of documents via the web and email and easy export of documents. Company RFID badges and key fobs provide secure access to documents at the board and automatic logout occurs after a period of inactivity. Users manage their documents with a web browser. Analytics and remote device management is provided for administrators. The IWB hardware consists of off-the-shelf components (a Hitachi UST Projector, SMART Technologies, Inc. IWB hardware, Mac Mini, Polycom speakerphone, etc.) and a custom occupancy sensor. The three back-end servers provide the web interface, document storage, stroke and audio streaming. Ease of use, security, and robustness sufficient for internal adoption was achieved. Five of the 10 boards installed at various Ricoh sites have been in daily or weekly use for the past year and total system downtime was less than an hour in 2012. Since CBRP was installed, 65 registered users, 9 of whom use the system regularly, have created over 2600 documents.

Keywords: whiteboard, cloud, collaboration, teleconference, pen interface, touch interface, sharing

1. INTRODUCTION

Interactive Whiteboards (IWBs) have been widely adopted in schools. Even though a majority of the estimated 12.5 million conference rooms worldwide contain whiteboards, IWBs have not gained significant adoption in business settings. Of the approximately 1 million IWBs sold annually, 94% go to the educational market and only 5% and 1% of annual sales are to corporate and government settings, respectively. Since there are more business locations for whiteboard use than classrooms, we infer that existing IWBs do not meet the needs of business users.

This paper summarizes unmet needs for IWBs in corporate settings identified through market analysis and customer research, including trials and interviews. It also describes the CloudBoard Research Platform (CBRP). A primary goal of the CBRP system was to create an interactive whiteboard that takes full advantage of the cloud in a way that addresses needs of corporate users. The CBRP includes hardware and software that was deployed at multiple internal Ricoh sites in order to study the usability of various technologies and systems. The CBRP system pictured in Figure 1 includes user and administrator web interfaces and is based on commercially available hardware along with custom software and web services.

1.1. Work by others

The CloudBoard Research Platform is a combination of an interactive whiteboard with cloud storage and a shared-strokes, audio-conferencing system. Research into video-conferencing with shared strokes goes back more than 25 years, but CBRP is most closely related to shared-stroke IWB systems.

In the early 1990’s, Ishii published a number of papers about his projector- and mirror-based videoconferencing system called ClearBoard. ClearBoard allowed users to maintain eye contact while talking face-to-face from remote locations. Users could share images by drawing on a half-silvered mirror through which the image of the remote user was

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The glass operated as a traditional whiteboard in that there were no electronic operations – just drawing and erasing with fluorescent color paint markers. Whatever was drawn on the board was captured and shared via video signal with the remote user. ClearBoard supported two simultaneous users. In the early 1990s, there were also activities related to shared strokes at Xerox PARC, including the VideoDraw, Commune and VideoWhiteboard systems.

Recent work in this area is ongoing by Robinson, et. al. at HP which uses laser projectors and notch color filters to separate the drawing image from the projected video.

An experimental IWB system developed at Xerox PARC around the same time as ClearBoard consisted of Liveboard hardware and Tivoli softwa...
1.2. Motivation

The CBRP vision is to create a device similar in size and functionality to a whiteboard that supports local and remote group collaboration and takes full advantage of the cloud. The CBRP web service provides secure access to documents. The system can be used to create shared documents during meetings and allow those documents to be reused in other meetings or later distributed as notes in printed or electronic form. While documents are frequently created from scratch, existing documents and presentations can be marked-up, providing an alternative to printed meeting handouts. A user’s documents are available from any CBRP client hardware and accessible on the web.

We surveyed a number of Ricoh customers, many of whom expressed a strong desire to be able to collaborate while using a whiteboard. Shared strokes for remote meetings was rated highest of desired features by respondents, with 70% indicating a desire to have the resulting documents available in an enterprise content management system or on the web.

One CEO we interviewed has engineering groups in Taiwan and Silicon Valley and felt that the ability to share drawings remotely during a meeting would overcome language barriers and significantly reduce the need for travel.

Previous IWB software and hardware targets the education market where the device is set up in a classroom occupied and managed by an individual teacher. A corporate setting is different in that multiple people utilize the IWB and the computer connected to it. For example, a teacher can keep classroom lessons on the IWB computer and lock the door when the day is over. Corporate management cannot leave sensitive presentation and meeting documents on a computer in a shared or open location.

1.3. Corporate user needs

Key user needs identified through user studies, surveys, interviews and market studies in a corporate setting include: instant on, ease of use, security, remote management, document management, collaboration and integration.

*Instant on*

In conference rooms where both an IWB and a whiteboard are available, we found that few people will wait the 30-40 seconds it takes for the projector to warm up to use the IWB. If the IWB is not ready to go, they will just pick up the pen and move right to the regular whiteboard. Experience shows that the delay causes an interruption in the thought process that was frequently detrimental to the discussion at hand. A particular challenge for the makers of IWBs using projectors is to create an “instant on” experience where the projector and software are ready to use at a moments notice.

The “occupancy sensor” custom hardware described in this paper supports an “instant on” experience.

*Ease of Use*

A large part of the cost of adopting new technology is the time invested in learning how to use it. In contrast to teachers who use an IWB for hours every day, corporate users are reluctant to spend time learning a new technology unless the benefits for adoption are clear. Devices used infrequently must have a simple interface and one that is easy to remember even if only used occasionally.

The “walk up and use” mode described in this paper supports use of the board by people with no training.

*Security*

Sensitive information left on a whiteboard in a common space can lead to serious problems within a company and may even violate the law. One of Ricoh’s major customers (40,000 employees in 300 locations) posts stickers on all of their corporate whiteboards reminding users to erase content after meetings in order to avoid accidental disclosure of corporate secrets. Banks must insure that social security numbers are never written on a whiteboard. Hospitals in the US must comply with HIPAA requirements and avoid disclosures of personal information in public spaces.

On traditional whiteboards it is impossible to enforce a requirement to erase boards. Even on IWBs, special effort is required to ensure that data stored on the controller is also erased. Existing IWB software typically stores content on local hard drives or storage attached to the network. For corporate use, IWBs must support several features, including erasing boards after meetings and preventing sensitive information from getting into the hands of unauthorized viewers.

CRBP uses IT controlled, cloud-based storage that combines conventional web-based document management with novel ways to access and share documents from an IWB.
Remote Management

Since IWBs cost thousands of dollars they are likely to be in shared spaces and conference rooms where no specific individual owns or is responsible for the device. Electronic hardware requires maintenance, including replacement of failed components and firmware upgrades. Usually the IT department is responsible for managing IWBs in a corporation. A system that provides centralized device management—a corporate IWB dashboard—could save the IT department significant amounts of time and money.

One Ricoh customer in the US installed 27 IWBs in their corporate headquarters. When we interviewed them, they had no idea if the boards were being used or even if they were functional.

The CBRP provides usage information, maintenance information such as projector bulb life and allows near real-time notification of IWB problems.

Collaboration

One consistent request from interviewees was to provide a whiteboard that could be used for collaboration. Video and audio conferencing could be significantly improved with the ability to share drawings. Interviews have shown that the ability to collaborate remotely by drawing was more important than sharing video for most users.

With CBRP, setting up an audio conference with whiteboard sharing just requires opening the same document on multiple boards.

Document Management

Whiteboards are one of the few devices in a corporate setting where information is created and organized, but not regularly captured and stored. Previous IWB software stores documents in proprietary file formats on the local hard drive or network drive mounted on the local computer. Since the file format is proprietary, it is impossible to search the filesystem by anything other than filename or creation and modification date. A preferred method of searching would be by thumbnail image, author, location of meeting or other information available to the IWB, but not to the filesystem.

Corporate IWB users need an easy method to search, sort and share IWB documents. In the survey mentioned previously, remote access to IWB content on the web was ranked as the second most important feature of an IWB, a feature not offered by previous IWB software or systems.

CBRP has simple document management functionality through a web interface and on the device.

Integration

Not only do users want to access documents on the web, but they want to be able to share the content with other users and easily move documents from one system to another using standard file formats. Proprietary IWB files make collaboration difficult. Successful IWB systems must include tools for translating to and from standard formats and provide an API for importing and exporting IWB files and images to and from Enterprise Content Management systems.

The CBRP web interface allows importing and exporting documents in standard formats such as Adobe PDF and popular image formats. CBRP documents can also be created via email.

1.4. Many small things done correctly

A great product and a great user experience is not the result of a single insight or feature, but many small things done correctly. The challenge in creating the CloudBoard Research Platform was not in meeting specific unmet needs in isolation or any single technical part of the platform (although there were many difficult technical pieces). The goal was to create a cohesive environment and system that was easy to learn and use and provided the right affordances and tools to meet the needs of corporate IWB users.

2. SYSTEM OVERVIEW

The CBRP requires a complex architecture because it supports document storage, access to documents using a web U/I, as well as stroke and audio streaming to multiple remote boards simultaneously. The platform must preserve security for the users so that they can use CBRP for sensitive or private discussions without fear that other users or administrators can see their information. Design for high availability is also essential. If a system is not available when people need to use it, it will not be adopted. We designed the system so that we would know immediately if it became unavailable so
that we could implement repairs promptly. CBRP integrates with Nagios\textsuperscript{10} monitoring software. Servers are actively monitored to quickly detect and isolate problems. IWBs (clients) typically report status every 10 minutes for passive monitoring.

![Architecture](image)

**Figure 2.** High-level architecture (left) and software architecture (right).

### 2.1. Server software architecture design

We chose 3 servers as shown in Figure 2 (left): Apache (http://httpd.apache.org/) + ZEND (http://www.zend.com/) for document storage and a web user interface, ActiveMQ (http://projects.apache.org/projects/activemq.html) for real-time stroke sharing and SylkServer (http://sylkserver.com/) for multi-point VOIP audio conferencing. The CBRP client (the software for the IWB) directly uploads and downloads documents from the CBRP server using HTTP, including document files and image files. The CBRP client communicates with the ActiveMQ server for sharing strokes. The pjsua VOIP client (http://www.pjsip.org/pjsua.htm) was integrated into the CBRP client to manage audio communication. We used MySQL to store and query the CBRP database. A Python program acted as an email client to upload documents using HTTP. See Figure 2 (right).

### 2.2. CBRP Hardware Platform

Selection of the best hardware for implementation of the CBRP was an iterative process. The most common final hardware configuration is described here and shown in Figure 3. Most of the hardware is commercially available.

A SMART Technologies, Inc. 16:10 aspect ratio SBX885 board acts as a 6x4 foot screen for a color projector. The board comes with 3 passive styluses, two pens and an eraser. SMART’s DViT sensors\textsuperscript{11} have 4 cameras and retro-reflective tape around the edge of the board to track two variable size pointers on the board simultaneously. The sensors can differentiate between an eraser, a pen, a finger and a fist touching the board.

A Hitachi CP-AW250N 2500 lumen projector is the system’s display. It includes HDMI input and can be controlled by software over the network. The 1280x800 resolution matches the 16:10 aspect ratio for the 885ix series board. We found this to be sufficient resolution to display a full page of normal text for marking up PDF documents. The Hitachi projector has image warping technology that simplifies the final alignment of the projector to the board by matching the 4 corners and 4 edges of the projected display within 1/2 pixel to the corners and edges of the board.

A custom occupancy sensor to detect people near the board was fashioned using Zilog ZEPIR0AAS02MODG ZMOTION Detection Modules and FTDI TTL-232RG-VREG3V3-WE USB to serial cables. A custom enclosure for mounting the sensor on the top or bottom of the SBX885 board was fabricated using a 3D printer. A Python program running on the controller receives sensor inputs, controls the projector and communicates status information as a localhost-only web service. This communication includes information provided by the projector such as bulb life.

The controller chosen to run the client software is a Mac Mini running OS X 10.6 and above. OS X has drivers for the SMART Board hardware, supports networking and connection of the various peripherals, and has good development tools for the GUI software. It is low power, small, and quiet enough to be mounted on the wall near the board. The Mac is connected to the LAN using the ethernet port or WiFi. A USB hub with ethernet was used to create a second private ethernet connection to the projector.
A pcProx RDR-6081AKU RFID reader is used for reading employee key fobs for IWB login. Additional ProxKey II Keyfob 1346LSSMN key fobs were distributed to users who did not already have a corporate key fob.

A Polycom CX100 Speakerphone is used for audio conferencing. This connects to the controller by USB and provides echo cancellation.

Installations used wall-mounting hardware for the projector, Mac mini and other peripherals. Appropriate length cables (e.g. a separately purchased 25 foot power cord for the projector) were secured with cable ties to achieve a tidy look.

### CloudBoard Research Platform Hardware

![CloudBoard Research Platform Hardware diagram](image)

Figure 3. CBRP hardware diagram.

3. **CBRP CLIENT SOFTWARE**

The client software was developed using the XCode IDE in Objective C on the Apple Mac platform. It can be used on the IWB setup or as a standalone client on any Mac computer.

3.1. **Typical Scenario**

When a user enters a conference room containing the CBRP, the occupancy sensor turns the projector on. The Hitachi projector takes about 40 seconds to warm up until it is ready to use. The image projected onto the IWB is a dark screen with the CBRP logo in the center. This image was chosen to minimize distraction when the CBRP is not needed but to indicate that it is ready to use.
If someone touches the CBRP screen, immediately a white screen is shown, along with a series of icons along the bottom of the screen, including pens, an eraser and a pop-up menu icon. This provides an “instant-on” experience for the user because there is no wait required for the projector bulb to warm up.

Once the white screen is shown, the user can select a pen and start drawing. If desired, the user can login to the board and the drawing will be saved to their account. The user's photo appears in the upper right corner of the screen. Multiple pages can be created, lines drawn and erased, strokes selected, copied and pasted, rotated or resized. Pen color and line width are selectable.

Previously created documents are easily retrieved for review or modification. If two users have the same document open simultaneously, the boards are connected with audio and stroke sharing.

When finished, the user can logout using the pop-up menu. However, if no one is in the room and the CBRP system detects that there is no local or remote activity for a preset length of time, the document is saved, the user logged out and the projector is automatically turned off, reducing energy consumption and noise and preserving bulb life.

If the user chooses not to log in, documents are not saved and the user's photo does not appear in the corner.

3.2. Logging in/out

Anyone can use the board without an account, but nothing is saved unless the user logs in.

When a user’s CBRP account is created, a RFID key fob and a password are associated with the account. In most cases, an employee’s existing key fob is used. To login, a user presents his or her key fob or card to the RFID reader on the side of the board as shown in Figure 4 (left). If the login is successful the anonymous user icon is replaced with the user’s picture in the upper right as shown in Figure 4 (right).

A user can manually log out using a menu item. At log out, the CBRP is cleared and the anonymous user icon appears in the upper right corner again.

Figure 4. RFID reader and key fob (left). Display with undo slider, menu, page thumbnails, icons for “walk up and use” mode and picture for logged-in user (right).

3.3. CBRP documents

A CRBP user works on a single document at a time. Each document has one or more pages. A page-oriented approach was taken, as opposed to a zoomable interface, to simplify the conversion to and from printable documents. The CBRP always displays a single page that fills the display. There are no affordances for zooming or scrolling the document. Documents are saved automatically to the user’s account on the CBRP web server every time a page is changed or after a period of inactivity.
3.4. “Walk up and use” mode and “natural interaction” mode

When the icons appear on the bottom of the screen, the user can select an icon in order to perform an action. Icons were chosen which are easy to understand at a quick glance. In “walk up and use” mode, the software operates identically whether a pen or finger is used to touch the screen. The user can select a colored pen (black, red, green, or blue as shown) or can choose the eraser icon to erase lines that are already drawn on the board.

The Menu icon pops up a menu (shown in Figure 5) in the center of the board and the finger icon switches to a selection tool. The menu allows the user to change the color or width of new strokes, to cut, copy or paste strokes or to interact with stored documents.

The SMART Board can distinguish between a finger, a pen, and a large object like a palm, fist, or eraser pressing on the board. If the CBRP user hides the “walk up and use” icons, the board will enter “natural interaction” mode where it will switch tools automatically based on whatever is touching the board.

Touching the board with a finger causes the software to automatically switch to the select tool. When a pen is used, “ink” will appear on the surface of the board. The eraser also works as expected. A user’s fist or palm can also be used to erase—something people do naturally on a whiteboard or chalkboard. A double tap brings up the menu at that location.

Speed is the key advantage of the “natural interaction” mode for experienced users because they are not required to keep reaching down to the bottom of the board to switch tools.

3.5. Manipulating strokes: drawing, eraser and selection tools

Lines act as objects when they are selected, move, rotated or scaled. However, the erase tool erases lines on a per-pixel basis, dividing single lines into multiple lines as needed. This combination of the pen and pixel-based eraser tools allows the interactive whiteboard to be used like a regular whiteboard.

The selection tool provides a new experience to the whiteboard user. Tapping on a stroke selects the whole stroke. Dragging over a region selects all of the region’s strokes. After selecting strokes, it is possible to modify them by moving them, making them larger or smaller, rotating them or deleting the entire selection. The strokes can also be copied and pasted. Figure 5 shows a group of selected strokes with UI for resizing, rotation, delete and duplicate.

Most whiteboard users have experienced the situation where the whiteboard is completely full, yet they need to add more information. Since CBRP strokes are objects, it’s possible to select all of them and shrink them slightly to make room for more information on the board.

To make neat text, some users create large text on the board in a location that is comfortable based on their height, and then shrink the text to hide imperfections in handwriting and move it to the desired location. CRBP users making lists would sometimes reorder list items or shrink part of a list to make room to add an additional item. Some users drew symbols and then copied and pasted them multiple times to create technical drawings.

3.6. Multiple pages

The CBRP supports multi-page whiteboard documents. Although there are arrow icons for changing pages, the client also supports a swipe gesture familiar to tablet and smartphone users for page changes.

When the menu is showing, thumbnails of the current document pages are drawn in the lower portion of the board (as shown in Figure 4 right). The current page is outlined in a red box. Tapping a thumbnail changes the display to that page and clicking on a cyan bar between thumbnails adds a new blank page at that location.
3.7. Accessing documents
After logging in, selecting “Docs” from the menu causes the CBRP to show thumbnails of documents stored on the web which are associated with the users account. If the user opens a stored document the old document is saved and the newly opened document appears in its place. The “New Doc” menu item works as expected, creating a single page document without strokes after saving the currently open document.

3.8. Undo
All operations on a document are time-stamped, including drawing, erasing and manipulating strokes. The user can roll back a page to its original state at anytime. There is no redo.

3.9. Sharing documents at a single CBRP
When one user is logged into the CBRP and a second user presents their RFID key fob to the board, either the open document is shared (Share) or the first user is logged out and the document closed and the second user is logged in (Switch). The user makes a choice using the dialog shown in Figure 6. Document sharing can also be initiated using the web interface.

3.10. Working Together Remotely on Two CBRPs
Using CBRP, many people can work on the same document simultaneously at different locations. Each user, at different boards, can open a shared document. When more than one CBRP has the same document open, a stroke sharing channel and an audio sharing channel is created. Each board includes a wall-mounted speakerphone for audio. All strokes made on one board are sent to all of the other boards in the session. The sharing system has been tested with as many as four boards at once.

During a shared stroke session, users are free to change to any page, draw strokes or transform existing strokes. Other users see those changes in real time if they are looking at the same page.

Documents in our system are shared but there is no server that maintains the current state of an actively shared document. Since there is no official “host” of the meeting – all clients are the same – the system designates a host that manages a synchronization process to make sure that all late-joining boards are up-to-date.

Users at remote boards sometimes simultaneously select and transform the same stroke. It’s usually obvious when such transformations conflict and it has been observed that typically one of the users stops while the other user finishes the move or rotate. CBRP is robust to simultaneous transformations.

Erasing causes a difficult race condition. If two people are erasing different parts of the same stroke at the same time, it’s possible for the system to create new partial strokes that overlap in such a way that it appears nothing was erased. To avoid this situation, only one board can erase at a time during a collaboration session.

4. CBRP WEB AND EMAIL INTERFACE FOR USERS
An important part of the CBRP system is the web-based document storage and user interface. Using a web browser, users and administrators can log in to the CBRP document server and access documents created on the client. New documents can be created by uploading images or PDF files using the interface shown in Figure 8 (left). Administrators can access analytics about how the boards are being used, create new accounts and monitor the clients and servers.

As shown on the left in Figure 7, the main web page contains a grid of thumbnails of recent documents and has links for creating a new document, converting PDF files and various administrative actions. Clicking on a thumbnail for a document opens a lightbox-style page viewer. Figure 7, right, shows a detail view of one thumbnail. Links under each thumbnail allow access to a document information page as well as earlier versions of the document. Each document’s information page contains a link to download the document as a PDF file, displays individual page images and has a UI for setting document permissions (Figure 8), title and notes. CBRP provides access control list (ACL) document sharing on the web server. Any user can share access to a document they own with any other user on the system. A document
owner can grant view (read only), edit (read and write but not delete or share) or own (read, write, delete, share) permissions to other users.

Users can also create CBRP documents by sending emails with attached PDF or image files to the CBRP server email address. For instance, the RII “Whiteboard Share” and “Scan Pages” iPhone apps can deliver content directly to the CBRP web server for conversion. Documents created on the Ricoh eQuill tablet can also be converted to CBRP documents. CBRP APIs can be used to integrate with other web services or even private corporate document management systems built on commercial content management systems.

5. CBRP WEB INTERFACE FOR ADMINISTRATORS

The CBRP web interface for administrators provides several pages for monitoring and managing user accounts and devices. CBRPs are listed by name and geographic location. A separate monitoring web service indicates the current status and history of all of the boards and servers and can send out notifications over email and SMS when there is a failure or imminent problem. The web UI can be used to create user accounts, obtain a list of emails for all users, reset passwords, upload user images, etc. Detailed board usage statistics can be inspected or downloaded.
6. USAGE SUMMARY

6.1. Users

65 users have registered to use the CBRP, 14 of those created more than 10 new documents in 2012 and 12 users logged in 10 or more times to the system (combined logins at the CBRP and on the website) in 2012. 13 users have logged in during the past 30 days.

Figure 9 shows statistics for average monthly user logins in 2012. For instance, 12 people logged in between 1 and 4 times per month. 9 users logged in 25 or more times in 2012 and 4 logged in more than 70 times in 2012, averaging more than one time per week. (Two of those are system developers and two have CBRP systems in their office space.) There were a total of 1143 logins in 2012 averaging just over 4.3 logins per weekday.

6.2. Cloud

A standard whiteboard does not allow reuse once the board has been erased. One of the unique advantages of the connection to the cloud includes reusing documents by accessing them on different devices or different days than the ones on which they were created.

We tracked 991 documents where the author logged in and created the document on the CBRP. Figure 10 illustrates that some cloud feature was used with 79% or 784 documents. Accessing a document from both a board and a PC via the web was the most common cloud use (699 documents) followed by accessing the same document on multiple days (472 documents).

6.3. Documents

On average, 6 new documents were created on the CBRP every 10 times the user logged in to a CBRP device.

We analyzed 1064 “non-blank” documents out of 1536 total documents. We arbitrarily chose any document with less than 10 strokes and no images to be considered blank and excluded any documents created by or shared with a test account.

Figure 11 shows the usage of strokes and images in documents. For instance, when a user draws on a blank IWB screen, the document is
considered “strokes” only. If the user uploads a PDF file and then marks up the document on the CBRP, the document is considered “strokes and images”. Users also upload documents for presentation only. 59% of the documents we analyzed were traditional whiteboard use with “strokes only” as shown in the figure. Note that the majority of documents had between 10 and 999 strokes on all of their pages. Only one test document had more than 10,000 strokes.

Figure 12 shows the usage of various whiteboard features for a collection of documents where strokes were drawn. The traditional feature of erasing (deleting strokes) was used in more documents than any of the advanced, IWB-only features (move, scale and rotate strokes) Figure 13 shows the distribution of the number of users who created a small number of documents versus the heavy users. Of the heavy users, two were not part of the project team. Table 1 shows the types of documents used by specific users (anonymized). Technical design and planning were the most frequent use. Table 2 shows the use of background images when creating documents by specific users.

Table 1. Types of documents created by various users (anonymized).

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<th>B</th>
<th>C</th>
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<th>F</th>
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<td>5</td>
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<td></td>
</tr>
<tr>
<td>Art / drawing</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Markup whiteboard photo</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>CBRP template</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Other with uploaded background</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>

Table 2. Total documents with an uploaded background by user (anonymized).

<table>
<thead>
<tr>
<th>Uploaded background</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uploaded background</td>
<td>98</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7</td>
</tr>
</tbody>
</table>
7. CONCLUSION

User needs for IWBs in a corporate setting were identified in the areas of instant on, ease of use, security, remote management, document management, collaboration and integration. The CBRP system allowed testing a number of theories and running experiments about technology for meeting these needs. A complete system, including a device + cloud infrastructure, was created with reasonable security that allowed corporate users to log into the CBRP using their existing credentials (key fobs or cards). Page-based documents for whiteboard interaction has proven effective, easy to understand and functional for many users. PDF upload and download, email, tablet and smartphone apps were integrated into the CBRP system. A variety of natural interactions were developed for CBRP, including swiping the screen to change pages, pen to write/finger to select and erase with the fist or palm. While there is still much work to do on the user interface, many users found the user experience acceptable or even pleasing. A flexible and robust multi-user, shared stroke, audio conferencing system was deployed and lightly tested. This included the development of a robust messaging architecture tightly coupled with the document management and storage system and a VOIP service. Web based document management for users and remote device management for administrators was deployed.

Since CBRP was installed, 65 registered users, 10 of whom use the system regularly, have created over 2600 documents. Five of the 10 boards installed at various Ricoh sites have been in daily or weekly use for the past year. Total system downtime is less than an hour in 2012. The CBRP system continues to be used in our organization after the conclusion of research activity.

ACKNOWLEDGEMENTS

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REFERENCES


