Figure 1. Office Central *picture window* at the Computer History Museum installation. The screen in this kiosk-style application shows an "advertisement" for a remote person who is available to chat.

Office Central

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Abstract

Using Office Central, remote workers can "advertise" their presence in public spaces within offices, such as break areas, lounges or cafeterias. The design concept is to encourage informal, unplanned interactions between remote workers and those who pass through the public spaces. In this prototype installation at the Computer History Museum in Mountain View, CA, we set up a lounge area with an Office Central *picture window* display (Figure 1). The local people in the lounge, wearing RFID tags for identification, could chat informally with remote people using a high-fidelity, CD-quality audio channel. The virtual meeting places included audio and video content, designed to be experienced jointly by the local and remote people. Some content was also tailored to the local people, updating as they approached the picture window display.

Keywords

User experience, collaborative work, distance collaboration, RFID, high-fidelity audio.

Project/problem statement

Across many industries, the workforce is becoming increasingly more distributed as companies do business globally and establish work-from-home programs. Although distributed work is fast becoming the norm, it is fraught with problems. Research has shown that communication decreases dramatically with distance [6] and that effective communication is an important

Figure 2. Storyboard sketches of an Office Central picture window in a corporate break area. The top image shows an advertisement for a person interested in talking about software. The bottom image shows a conversation between a group of local people and a group of remote people.

factor in successful business outcomes. In addition, lack of opportunity to build relationships through social interactions decreases trust, and trust among co-workers is equally important in fostering team effectiveness. Distance also makes it difficult to detect psychological state, increasing the chances that discontent will not be addressed in a timely fashion. Finally, remote workers often suffer from feelings of isolation. This contributes to worker dissatisfaction and decreased loyalty to the organization. Powell, Piccoli and Ives' review of virtual teams documents these and other problems with distributed work [9].

The Office Central project is an attempt to bridge the divide between local and remote workers. The goal is to use technology to increase effective communication, provide opportunities for social exchanges, and help remote people to feel almost as if they are local. Babson College management professor Farshad Rafii calls this phenomenon "virtual co-location" [7].

Background

The Office Central project is one in a series of projects at Sun Microsystems Laboratories focused on improving the collaborative experience of remote co-workers. The system described in this paper was created for an installation at a two-day corporate open house at the Computer History Museum in Mountain View, CA. The audience included Sun Microsystems' employees and customers as well as press and analysts. The purpose of the installation was to give visitors a flavor for what will be possible with collaboration technology in the future.

The team included the following people and roles:

Nicole Yankelovich, project lead, UI design
Karl Haberl, manager, audio engineer
Mike Wessler, user interface software
Jonathan Kaplan, backend software
Joe Provino, voice and audio software
Nigel Simpson, multimedia software
Justin Matejka, RFID software
Chris LeDantec, visual design

Office Central represents a six-month effort for the team, with planning for the project beginning in the Fall of 2004 and the installation taking place the last week in April 2005.

Challenge

Office Central was a project with many significant challenges. First was paring down the team's ideas to a manageable subset given the 6-month timeframe for the project. We created storyboards for a set of features we thought we could accomplish on an aggressive schedule (Figure 2 shows two samples).

A requirement for the installation was to create a hands-on experience for visitors. One of our primary challenges was creating a look and feel that was simple enough for first-time users, but also showed off new, unfamiliar technology. Since we were trying to create a futuristic impression, we intentionally avoided using any standard look and feel. We even expended effort looking for a simple, but uncommon, input device to get across the idea that collaborating in the future could be done "at the press of a button."

Another major challenge was figuring out how to identify people in the lounge to remote users. We wanted to know who was in the lounge and we also

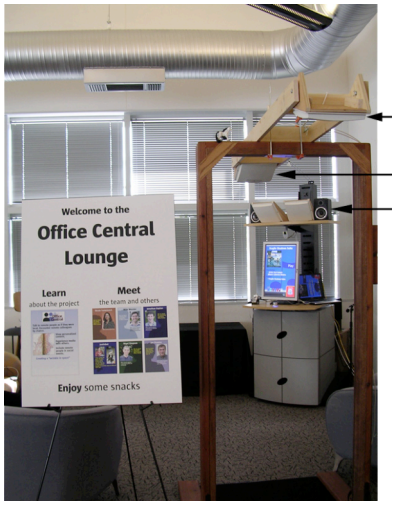

Figure 3. In the Office Central Lounge, the four RFID antennas are visible above the doorframe and above the Picture Window display.

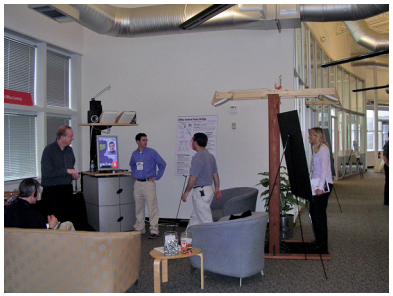

Figure 4. As visitors enter the lounge, the antenna on the top left of the doorframe detects their presence. The one on the top right detects when someone leaves the space.

wanted to know which of those people were in the *hot spot* – the area in front of the display in reaching distance from the input device. Any identification tags or other technology had to be inexpensive enough for us to give one to all the projected 500 attendees.

Passive RFID (radio frequency identification) tags, at approximately $1.00 per tag, seemed like our only practical option. These tags, however, are designed to attach to packages, not to people. When the RFID equipment arrived in our Lab only weeks before the event, we discovered two major issues to overcome. The antennas could only read the tags from a few inches away when worn on a person, and we needed a read-range of at least 5 or 6 feet. In addition, the antennas only read the tags intermittently. This gave us the effect of people in range of the antennas appearing and disappearing randomly.

Other challenges included addressing privacy concerns related to the use of RFID technology, designing the installation for a space that no members of the team would be able to see in person before the event, and tackling the problem of echo when using powerful microphones and speakers.

Solution

Process

The fundamental ideas embodied in Office Central are an outgrowth of years of user research we conducted related to distance collaboration. We know, for example, that audio quality is a crucial factor when it comes to remote interaction. Poor audio quality is highly correlated with ineffective distributed meetings. We also know that knowing who you are speaking to and who is listening to you are other important factors in remote collaboration [12].

Our process involved analyzing our user research data and then brainstorming extensively about user scenarios and possible feature sets to support those scenarios.

When considering new ideas, we wanted to satisfy a number of constraints. Our installation had to demonstrate ideas that were consistent with solving problems uncovered by our user research. Our management wanted a demonstration that reflected our research organization's history of innovation and futuristic thinking. They also wanted us to create an interactive user experience so that visitors could experience the technology first-hand.

User Experience

A visitor to the installation was first directed to a registration area. Here they could see another demonstration of our related Meeting Central project [11, 12] and receive a personalized RFID tag. This tag, designed to be attached to a conference-style badge holder, was associated with the visitor's name and email address.

After registering, visitors were invited into the Office Central Lounge. Access to the lounge was through a wooden doorframe – once used as a stage prop. Two RFID antennas were mounted on top of the frame to identify people as they entered and left the space (Figures 3 & 4). The area itself included comfortable seating, a table with snacks, and a *picture window* – our version of a walk-up-and-use kiosk. Two more RFID antennas were mounted above the picture window to

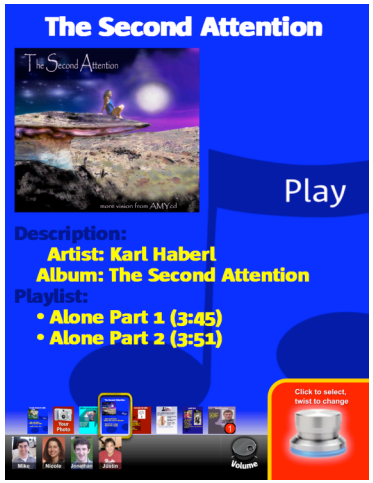

Figure 5. Music ad.

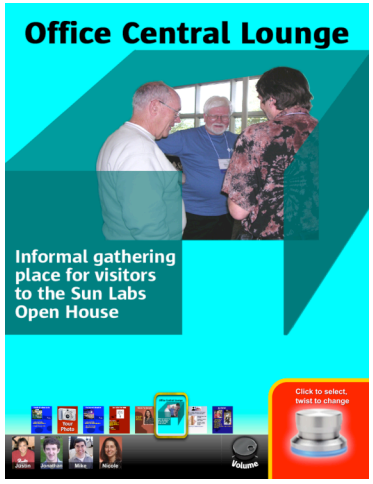

Figure 6. Ad for a virtual space. This one corresponds to the physical space of the same name. When remote people join, they will see video of the space.

identify who was standing in the hot spot. Stereo speakers, two microphones and a video camera were also attached to the picture window.

On entering the lounge, the picture window would greet first-time visitors by name and ask them if they would like to have their photo taken. Photos are used in the system to display images of the local people to remote participants. They also appear in the *person radar* section of the picture window (see bottom left in Figure 7) to show who is in range of the RFID antennas.

We implemented a fully automated picture-taking application using a video web camera (Figures 10 & 11). If the visitor agreed to be photographed, they could see a preview of the photo in the picture window. Once the picture was taken, they could choose to save it or retake it. As soon as the picture is saved, it appears as a thumbnail in the person radar and is available to remote users.

In the absence of any explicit user input, the picture window starts displaying *advertisements*. These are either for virtual spaces or for remote people who are currently interested in chatting. The spaces may include audio or video content. For the installation, we created a space with a playlist of songs from our colleague's band (Figure 5), a virtual Office Central Lounge (Figure 6), and several spaces with entertaining corporate videos. Thumbnails of these ads appear just above the person radar so that a visitor can navigate directly to one if desired.

If an ad looks interesting, any visitor near the picture window can press the PowerMate knob. This is a peripheral device that can be pressed and/or twisted to activate the content associated with the ad (shown in front of monitor in Figure 10). If a visitor selects the Office Central Lounge ad (Figure 6), a high-quality audio channel is opened between the Lounge and the remote person (Figure 7).

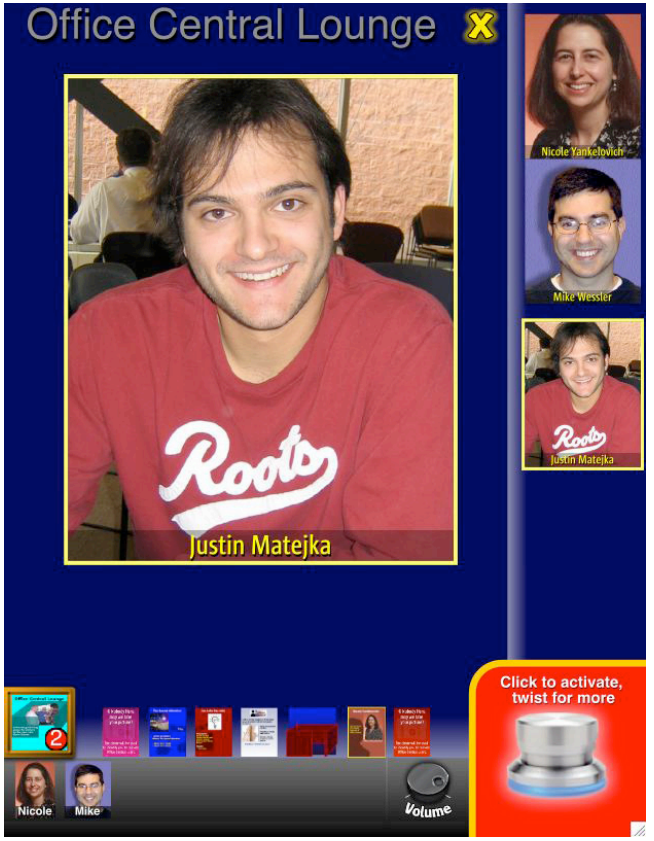

Figure 7. Interacting in the virtual lounge. Nicole and Mike are standing in front of the picture window in the physical lounge, as seen by their photos in the person radar (bottom left). They are chatting with Justin. His image is highlighted, indicating that he is currently speaking.

Figure 8. The labels that the RFID tags were affixed to were rolled to keep the tags away from people's bodies. The tags are located directly under the Office Central logo.

Figure 9. The registration application associates RFID tag IDs with a person's name and email address.

The remote person, Justin in this example, sees the names and photos of all the people in the physical Lounge as well as a video stream of the space (not pictured). With the placement of the two high-quality microphones in the physical lounge, the remote person can also hear people's voices coming from different locations in the stereo field.

Presence information about public spaces can be viewed by other users of the system. For example, if the people in the physical lounge are chatting with Justin in the virtual lounge, another remote user, Jon, could see that there is activity in the virtual lounge. He knows this because a badge appears on the space's thumbnail (red circle with number 2 in Figure 7). Jon can then twist his PowerMate knob to select the ad for the Lounge. A single press on the knob connects Jon to the conversation. Note in Figures 5, 6, 7, 11, and 12 that the bottom right corner of the screen prominently displays help text indicating what will happen at the current moment if the PowerMate is pressed or twisted. Once Jon enters the space, his photo immediately appears to everyone there. As he speaks, his photo is highlighted dynamically.

In addition to ads for people and virtual spaces, we created ads for media rooms. By selecting one of these, visitors could watch videos or listen to music. We designed these rooms as collaborative spaces in which multiple remote people could experience the media together and talk to one another about it. For the installation, however, visitors were only able to play the media on their own. They were not able to get the full experience of listening to or watching the content with remote people.

Technology Details

Office Central is written entirely in the Java™ Programming Language. This includes the VoIP (voice over internet protocol) audio bridge that mixes the high-fidelity audio channels and detects who is speaking.

The Office Central application, which runs on a laptop in the kiosk, is built on top of our distributed SPOC (single point of contact) Framework [12]. This is an extensible platform for developing collaborative applications that are secure, scalable, and easily integrated with communication tools.

We selected Griffin Technology's PowerMate device as our input device. Made of high-quality machined aluminum, this device offered the single button press simplicity we were after. It also had the added flexibility of being able to twist the knob, which allowed us to support simple navigation between ads and intuitive volume control for multi-media content. The blue glow around the bottom of the device, seen in Figure 10, provided a bit of futuristic aura.

For the RFID technology, we used passive tags operating at 915 mhz. To overcome the problem of the tags not working when in contact with humans, we rolled the labels containing the tags, which created an inch of space between the tag and the person's body as shown in Figure 8. We also implemented a smoothing function so that people did not appear and disappear from the person radar due to the intermittent nature of the tag reads.

In the lounge, we had a single RFID reader connected to four circular-polarized antennas. The two antennas

Figure 10. Picture-taking ad with camera and PowerMate.

Figure 11. Using the application.

over the picture window were angled down, creating the hot spot, so that only people within a 6-foot radius of the display were detected. This hot spot was used by the picture-taking application (Figures 10 & 11), only offering to take photos of people close enough to press the PowerMate.

The two antennas mounted on the doorframe were angled such that the one inside the Lounge detected people walking into the space and the one on the outside detected people leaving (Figure 4). We found that given the short range of the tags, an instrumented doorway was the only way to reliably tell if people were still in the Lounge. We could not find any configuration of antennas that detected tags in all portions of the relatively small space.

In the registration area we had a second RFID reader and a single antenna. To register users, we would hang a tag in front of the antenna and enter a visitor's name and email address into our registration application (Figure 9). This associated the person's name with a unique tag ID.

RESULTS

The two days of the Sun Labs Open House were well attended, with a total of 620 visitors. Our goal for the Office Central installation was to attract visitors to interact, spur conversation, and help enforce our Lab's image as an innovative and future-looking organization. Since we did no formal evaluation, it is not possible to tell if our goal was completely met, but the event, in general, received good press coverage [8] and we had a steady flow of visitors in the Lounge interacting with the system. The picture-taking application did its job of drawing visitors into a hands-on experience.

Given that Office Central gathers presence information, we took several pro-active steps to alleviate privacy concerns. First, our choice of passive RFID tags ensured that people were only identified in close proximity to the RFID antennas. We also made a conscience effort to delimit the Lounge space so that people could easily avoid entering it. Finally, the separate registration process allowed people to opt in only if they wanted to participate.

Even with these efforts to alleviate privacy concerns, we anticipated that privacy would be a major issue for visitors. In a previous project called Awarenex in which we displayed computer and telephone activity of remote colleagues [10], the privacy issue came up in every demo. With Office Central, however, only one visitor raised privacy concerns.

We believe several factors contributed to this relative lack of concern about "being tracked." First, we were not tracking people throughout the entire event space, just in two well-delimited spaces that visitors could avoid if they wanted. For visitors that did register, we explained that they could disable the RFID detection by placing their hand over the tag. This empowered them to opt out at any time, even when they were in range of the antennas. The visibility of the antennas – which we had despaired about due to their unsightly appearance – turned into an advantage. Because of their large, bulky size and the close proximity we needed them to the tags, it was absolutely clear to people when they were in range to be identified. Visitors seemed to find the limited read range of the antennas reassuring, and the person radar gave them an effective visualization of this range. Finally, visitors

Figure 12. Person ad. One press on the PowerMate initiates an audio connection with the person advertising.

liked the features enabled by the tags. They experienced the convenience of not having to log in and also some examples of personalization made possible with automatic identification.

The personalization, in fact, was probably the aspect of the installation that most captivated visitors. They found it compelling to be greeted by name upon entering the lounge and most walked in and out a few times in order to watch their photo appear and disappear. Just as we expected some people to worry about privacy, we also were concerned that people might not want their picture taken. Although the software allowed people to easily opt out, all visitors who approached the picture window chose to be photographed. There was a fun factor in having a completely automated system take the pictures and also a motivation to add pictures since their use was immediately apparent.

The collaboration features prompted visitors to speculate how a system like Office Central could be used in their own environment. For example, an art professor thought a system like Office Central would be useful for art students remotely sharing and critiquing one another's work. A field salesman who had recently become a "flex worker" (one with no assigned office) thought Office Central could help him stay in touch with his team members.

The ability to easily interact with other people is one of the aspects of Office Central that makes it unique from other walk-up kiosk systems. With a standard kiosk, most people expect to be able to interact with a computer, but it is surprising to be able to talk to other people without any advanced planning. A single button press is all that is needed to open up a communication channel (Figure 12).

Our work is also different from many of the interesting "Hole in Space" [4] inspired projects in which two or more physical spaces are connected via an always-on video and/or audio link [1, 2, 3, 5]. Our focus is more on helping isolated individuals connect to co-workers, some of whom might be gathered in a physical space. The concept of advertisements allows these isolated people to express their interest in interacting with others without the use of an always-on connection. While these always-on setups are interesting, they also raise concerns about surveillance and privacy. Our design requires an explicit action to open a connection. This avoids the privacy issues while allowing many more combinations of people to connect than would be possible between a small number of instrumented spaces.

Another unique aspect of the system is that it identifies you without the need for any explicit action. There is no login sequence or card swipe necessary. Not only does the system identify you, but it identifies all the other people around you. Effectively, multiple people can be logged in simultaneously.

One aspect of the system that we had hoped to demonstrate, but did not effectively accomplish, was giving people a sense of being in the same space with the remote people by letting them experience the spatialized audio. While the high-fidelity audio functionality worked, it was nearly impossible to demonstrate it effectively in such a wide-open, noisy environment. In our future work, we are focusing on better echo cancellation techniques and better audio

configurations for demonstrating the potential benefits of high-fidelity audio without requiring visitors to wear headsets.

We also plan to complete the multi-media virtual spaces so that distributed people can listen to music or watch videos together. Particularly with the audio spaces, we hope this will enable distributed colleagues to hang out together listening to music, talking occasionally as if they were across the hall from one another. If we can create a virtual space in which people feel enough like they are in it together, we will have effectively created the sort of virtual co-location that will help increase communication, build trust and reduce feelings of isolation.

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