This scenario is routine for people working in the same office. But imagine it takes place while working from home, including running into someone at some distant airport. Enabling such opportunistic interactions among people in different physical locations has been the goal of many technology projects dating back at least 15 years. For good reason; as insignificant as they may seem, these impromptu interactions greatly improve a team’s ability to function. They help it produce higher-quality products, stay more coordinated and motivated, and complete projects faster than those unable to have such nimble interaction [7, 8]. In fact, although they make up over half of all office interactions (estimates range from 51% to 93%), most happen among people no more than 30 meters apart [7, 12]. As more people work from home or on the road with people at still other sites, they increasingly need to maintain their connections, as well as those with family and friends [10].

Many academic and corporate research projects have connected members of distributed teams through video and/or audio conferencing, allowing them to notice one another and interact as needed [1, 5]. More recently, researchers have used text-based systems to support lightweight communication, including multiway chat and multi-user domains (MUDs) [2, 3]. Text-based messaging systems on cell phones have become popular, especially among teens around the world [4]. While these systems and others have helped people stay connected, none has combined the elements of awareness, lightweight communication, and mobility. One exception is the interesting Awarenex research system [11], but we thought more could be done to support awareness, especially in the form of opportunistic exchanges.

When we began the Hubbub project at AT&T Labs in 1999, our goal was to create a system that would encourage opportunistic interactions and support background awareness, while recognizing the fluidity of people’s movements throughout the day. The result was the Hubbub instant messenger (IM) application designed to run on PCs and Palm handhelds with a Minstrel wireless modem (see www.HubbubMe.com). Hubbub supports awareness and impromptu interaction through musical representations of users’ buddies, notifying them when these buddies are around in cyberspace, possibly available for interaction. It supports mobility in part by run-

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ubiquitous computing is not only influencing our lives, but our livelihoods. Indeed, traditional career choices and paths will require fundamental attitude adjustments.

Hubbub notices their locations and routes messages to them so they don't have to update their locations and others don't have to choose a destination. Hubbub makes it even more straightforward to send messages by introducing the concept of “sound instant messages” that can be sent and interpreted with minimal effort.

As part of the development process, we conducted a usage study in which we gave Hubbub to a small group of mobile professionals, observed their interactions, and repeatedly iterated the system based on the group's experience and opinions. Here we describe Hubbub and some of the findings from the study.

Like all IM applications, Hubbub shows the user's list of buddies, called “bubs” (see Figure 1). Their names appear in bold if they are active, that is, they have used their computer or handheld within the last five minutes or in regular typeface if they are idle but running Hubbub. The middle column shows how long each bub has been active or idle, giving the user a context for deciding whether to contact someone. Each user also has a “sound ID,” a short string of notes from a song, representing just him or herself. Each time a bub becomes active after being idle or offline, a sound plays (two rising notes) indicating someone became active, followed by that bub's sound ID, letting each of their bubs know who just became active. These “activity sounds” let users notice when their colleagues have returned to their computers, possibly reminding them of topics they want to discuss. If not, just hearing their activity reminds them of the bubs’ presence, helping them all feel connected. (These sounds can be muted, and specific people's sounds can be turned off, so users hear only the comings and goings of those they wish to be aware of.)

Hubbub provides more context to help determine a good time to interact, which can be difficult to coordinate with some IMs [9]. To the left of each bub's name is an activity meter reflecting that bub's activity over the past 15 seconds; it is empty if the person has not used an input device during that time; it may also be low, medium, or high, depending how actively they have been typing, clicking, or tapping. If a bub's meter is not empty, the bub is likely to be there. The far-right column in the interface indicates which device the bub is using (Palm or PC), followed by a short free-form message, typically indicating the bub's physical location. These cues help users understand their bubs' contexts. For example, if a bub is on a Palm and shows the location “in staff meeting,” the user might approach that bub differently if at all) from if they were on a PC at “home.”

Figure 2 shows a conversation on a Palm and a PC. On a Palm, users tap a bub's name to view their information screen (left) from which they initiate a text message (right). Users can also send sound messages, short strings of notes, or “earcons” with predefined meanings. For example, users who want to say “Hi” to a spouse click the “Hi” button; the spouse hears the user's sound ID followed by the “Hi” sound. When a sound message is sent, the sound plays, and the icon appears in the conversation. The sound messages are intended to be lightweight (in terms of both user effort and bandwidth) and fun to exchange. Typical sound message exchanges are “Talk?” followed by “OK” or “Thanks” followed by “No problem.”

To assure privacy, Hubbub membership is reciprocal and requires permission. If users want to revoke someone's permission to be part of a bub list, they remove them from their lists and are simultaneously removed from that person's list. Users can also block each of their bubs from seeing their activity (time

![Figure 1. (a) Hubbub on a Palm handheld and (b) on a PC.](image-url)
and/or location.

Hubbub helps users with low-bandwidth intermittent network connections see exactly when a message is received, eliminating confusion about who saw which messages when. If a message is not received quickly, the sender's client resends it until it receives receipt confirmation. Hubbub also accommodates people working from multiple locations. Users can run Hubbub from many places at once, leaving one and becoming active in another; Hubbub notices and displays the new location, sending any messages to the newly active client. When users exchange messages, they see which type of device their partners are on and whether they are typing in the window. All these features help users coordinate their activities during interactions.

**Awareness and Opportunistic Interaction**

We observed about 25 people using Hubbub (Aug. 2000–Jan. 2001), including researchers, managers, administrative assistants, and software engineers. About two thirds worked in New Jersey, the rest in California; one was in Texas. Nearly 50% ran Hubbub from home and work (some also on laptops); three worked exclusively from home. Three used Hubbub on a wireless Palm. The Hubbub team logged all Hubbub activity (capturing more than 3,000 conversations), asked the participants to answer surveys, interviewed them, collected their ideas through an email feedback feature, and talked to them informally through Hubbub and in person.

We found that Hubbub helped them feel more connected to their colleagues around the country [6]. Although they could have muted their bubs' activity sounds, only five opted to do so. The rest listened to everyone’s sounds or turned off only some. On average, all participants listened to nine of their 15 bubs, interacting with seven of them. Apparently, they wanted to feel connected to people they didn’t necessarily chat with.

Study participants reported that Hubbub helped them feel closer to other users on the opposite coast. One New Jersey manager said that by seeing a California colleague through Hubbub, “I know she’s there. In some respects if she’s not up here and I don’t see her, I don’t think about her, I mean, for better or worse. But when she’s there, she’s sort of closer to the front of your consciousness.” Interestingly, he never had a conversation with her, yet he clearly liked seeing her in his bub list. The California colleague said, “I think I glance at Hubbub about five or six times a day just to see who is on ... Friday is often a slow day around here; it’s nice to get a sense of virtual companionship.” Another participant said, “The sense of community was especially important to me as a contractor working from home all day long, being somewhat of an outsider to begin with.”

Many participants reported that running Hubbub from home made them feel more connected to their colleagues at work. After using it at work for two months, one said, “I have used Hubbub at home recently for the first time (new laptop), and it’s great; it gives me the sense that I am not alone.” Hubbub was especially helpful bridging time zones. Hubbub users online over a weekend frequently greeted one another, increasing their sense of comradeship. Later in the study, when some participants gave Hubbub to their spouses, their usage rate increased as they frequently checked in and coordinated home and parenting activities.

Some participants found the sounds annoying; some even chose not to use Hubbub because of them. One nonuser said, “The thing that makes Hubbub cool is the thing that makes it annoying.” Initially, Hubbub also played sounds when bubs went idle, but participants asked us to remove these sounds because they were too noisy and weren’t helpful. After we
removed them, at least one person complained there was “less of a Hubbub.” Only a few learned all the sounds without looking, though most learned the sound IDs of their closest colleagues, along with the most popular sound IDs (“Hi,” “Bye,” and “OK”). For some, just hearing other people’s sounds made them feel connected, even if they didn’t know which people they represented.

Did the feeling of connectedness lead to opportunistic interactions triggered by noticing someone’s presence? Our conversation logs show it did. We took as a rough measure of opportunistic interaction the percentage of interactions initiated within two minutes of a recipient becoming active, figuring that hearing the sound could have caused the sender to initiate the interaction. By this measure, 24% of the conversations were opportunistic, similar to the result reported in [7]—that 21% of face-to-face office interactions were started by a “sighting” that led to an unanticipated interaction. We also saw some cases (only 22 out of more than 3,000) in which two people simply exchanged “Hi” sound messages, indicating that Hubbub is sometimes used to make a connection simply.

Study participants generally used Hubbub messaging in two ways: to “coordinate,” or arrange face-to-face meetings, request phone calls, organize activities, and request tasks; and to “collaborate,” or engage in frequent (5 to 15) interactions per day, ranging from technical discussions to social chit chat. For example, they discussed corporate reorganizations, commiserated about departing colleagues, collaborated on presentations, and debugged technical problems. They interspersed these work topics with social ones, discussing vacations, political events, health problems, and news of family and friends. They also bantered, teased, and joked. That is, participants using Hubbub to collaborate used it to do just what they would otherwise do when working closely together in person.

**Group Awareness**

Although IM supports only pairwise interaction, we saw inklings in the study that Hubbub helped its users feel more connected to groups. For example, participants developed a convention of using the location field to broadcast information about local weather and local events, turning the feature into a sort of dynamic bulletin board, as in Figure 1. When the East Coast of the U.S. was hit by a blizzard, some updated their locations to indicate snow accumulation. When California experienced rolling blackouts, others on battery-powered laptops notified the group. When one traveled to Europe, he received messages from others just saying “Hi” to him in Copenhagen and then in Berlin. Sometimes people riffed off of one another. Following the weather theme, one participant made his location “MP, raining, no frogs”—a reference to the 1999 movie Magnolia—to which another replied “Los Altos, frogs, no rain.”

Sound IDs also contributed to a sense of camaraderie, revealing information about each user. An administrative assistant chose the theme from the movie Mission Impossible to convey her feelings about her job; another chose “Banana Boat Song” because it was happy and upbeat; another used hard-core rock-and-roll, saying she liked that it made people question their assumptions about her.

We have been asked why Hubbub doesn’t let its users choose which sound ID to associate with each of their bubs. Our experience is that our approach helps build a sense of community, allowing Hubbub users to build up common knowledge about which song represents which person (and theorize about the reasons for their choices).

**Mobility**

Hubbub supports mobility by both running on a mobile device and enabling users to move effortlessly among multiple fixed locations. We found the latter to be more important than the former. About 40% of study participants ran Hubbub from multiple locations, typically from home and work, and occasionally from temporary locations when traveling. When they left home, their colleagues saw them go idle and later become active at work. Wherever they were, messages appeared at their active locations without either party specifying a location. Many participants worked from home sporadically, but their colleagues could readily contact them without first knowing their whereabouts. In the early part of the study, we saw situations where participants missed messages that arrived immediately after they left one location, so we added a feature to resend those messages to the next client on which they became active, making mobile use even smoother. Moreover, Hubbub’s multidevice architecture helped bridge time zones, extending the time when users were available for quick conversations.

Only three study participants actively used Hubbub
on the Palm; few others had wireless modems, which were then (as now) expensive. Still, we found their behavior interesting, as it showed the potential for always-on mobile devices if and when prices come down. One of them used Palm Hubbub mainly while traveling; the other two also used it while in meetings, at conferences, and on local errands. For all three, Palm conversations made up 20%, 10%, and 8% respectively of their conversations during the study.

One of these users reported, “At one point, I’d been using it reasonably often, and I went up to Toronto. The guy I was working with gave me an office, and I’m sitting there and there’s no music, there’s no radio, there’s nothing ... I’m sort of playing around with the computer. And then I put [Palm Hubbub] on, and it was like I missed everyone. And ... every once in a while there’s some noise, and you see what people are doing and feel connected, or at least that you had some sense of what the group was doing.” Another Palm user was in a meeting where someone asked a question another Hubbub user could answer. She exchanged messages and relayed the response to the group, which, she said, was pleasantly surprised to get an answer quickly and unobtrusively. Perhaps our favorite example of mobile usage occurred when a study participant was stranded at an airport during an almost five-hour flight delay. She spent three hours chatting with her husband at home, staying calm while other passengers stewed in frustration. Later, both traveler and husband said they would not have spoken on the phone that long, but they liked being able to “hang out together” through Hubbub.

The biggest problems we observed with the wireless Palm were the connection’s lack of stability and the patience needed to write substantive messages. We quickly discovered it was critical for Hubbub to let users know when their messages had arrived and the status of their connections. Once Hubbub did so, conversations became less confusing and labored. Surprisingly, Palm-PC conversations included no fewer turns than PC-PC conversation and gaps between turns that were no longer. Instead, Palm conversations included shorter messages (with more typos) and more sound messages, which are easy to send. Apparently, the impediments of a wireless Palm did not deter study participants from having extended conversations.

Conclusion
Today, over a year and a half after we completed the study, there are more than 1,200 registered Hubbub users, primarily in the U.S. and Europe; about 400 log in at least once during any given week. Hubbub has succeeded in supporting awareness and lightweight communication among a distributed and mobile group of professionals. It works because it lets them be aware of one another effortlessly and because it provides many cues to help them in distributed locations initiate interactions and track one another’s attention while interacting. Moreover, it allows them to move about—either from one computer to another or with a mobile device—without specifying location and without missing messages. Sounds have proved critical for providing background awareness cues and for giving Hubbub its personality, though not all study participants found the sounds pleasant or learned the meaning of all the sounds. While we look forward to the day rich media-based systems support such a connection, we are pleased that the Hubbub text- and sound-based system provides the type of connection needed in today’s distributed workplace.

References

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Hubbub is available for download at www.HubbubMe.com.

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