

Beyond ‘yesterday’s tomorrow’: Towards the design of awareness technologies for the contemporary worker

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ABSTRACT

Modern office work practices increasingly breach traditional boundaries of time and place, increasing breakdowns workers encounter when coordinating interactions with colleagues. We conducted interviews with 12 workers and identified key problems introduced by these practices. To address these problems we developed myUnity, a fully functional platform enabling rich workplace awareness and coordination. myUnity is one of the first integrated platforms to span mobile and desktop environments, both in terms of access and sensing. It uses multiple sources to report user location, availability, tasks, and communication channels. A pilot field study of myUnity demonstrated the significant value of pervasive access to workplace awareness and communication facilities, as well as positive behavioral change in day-to-day communication practices for most users. We present resulting insights about the utility of awareness technology in flexible work environments.

Author Keywords

awareness, workplace studies, mobile communication

ACM Classification Keywords

H5.m Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms

Human Factors

INTRODUCTION

A shift is taking place in the modern office: being “at work” no longer implies being physically at a desk in an office building. Workers are increasingly mobile, on both a small and large scale. Increasingly work is being conducted outside the conventional “9-to-5” Monday through Friday work schedule. This shift is occurring due to pressures from globalization, soaring transportation costs, environmental concerns, technological advancement, and desire for a healthy work-life balance. The US President’s Council of Economic Advisors reports that nearly half of US employers have adopted flexible policies governing when and where employees complete their work. Nearly

15% of employees work at least one day a week out of the office [31]. A Gartner report [13] claims that as much as 25% of office work has become “non-routine,” characterized as working less rigid hours, and/or in a variety of places. This statistic is expected to jump to 40% by 2015.

At the same time, the volume of peer-to-peer interactions necessary to successfully perform work tasks remains high in most professional domains. González and Mark [14] summarize several studies showing that workers spend a majority of their time in direct communication with peers. With assumptions about a colleague’s location and availability now more uncertain than ever, communication breakdowns are becoming both more frequent and costly.

While there has been work in building systems to address this challenge, much of the existing work is designed for a previous generation of workers. New design challenges have emerged; the critical importance of mobile devices in the day-to-day lives of workers and the explosion of communication tools used in the office [28] are just some examples of this changing landscape.

We conducted structured interviews to identify breakdowns induced by this new environment. Results show that information needs transcend time and space constraints, which in turn introduce new challenges for how colleagues communicate. Our findings further illustrate the difficulty workers have in mediating *immediacy* and *preference* in their selection of a communication channel. The increase in communication capabilities also creates a tension between being *engaged* in a particular communication event while being *available* to engage in others. These and other findings were used to generate a set of functional requirements for modern awareness systems. We then designed and built myUnity, a fully functioning prototype embodying these requirements. In particular, myUnity is the first system that supports both information collection and dissemination across multiple platforms (desktop and mobile), aggregating data from automatic sensors and existing systems (e.g., calendars, IM).

Finally, to gain an initial understanding of its value, we describe a field deployment of myUnity, which provides a validation of our functional requirements. Our results suggest the importance of pervasive access to awareness and communication facilities in general and of systems that integrate the desktop and mobile experience in particular. Taken as a whole, the results demonstrate the value of technologies like myUnity to improve the contemporary communication landscape.

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RELATED WORK

We review existing awareness tools, describe past studies of these tools, and discuss the broader field of research related to the study of awareness and communication tools.

Awareness in the Workplace

Dourish and Bellotti [8] studied how workers collaborate to write papers. They found that an ongoing understanding of others' activities was necessary for effective coordination on group tasks. Erickson and Kellogg [9] argue that *Social Translucence* (visibility, awareness, and accountability) is an important social cue in communication mediated by computers. Begole et al. [3] and Reddy and Dourish [22] observed that workers exhibit periodic, predictable behaviors, or *rhythms*, that are often perceived by colleagues and, when well understood, assist in decisions on how or when to establish contact. Our work builds on these, providing a platform that enables workers to quickly understand workplace rhythms and ongoing individual and group activities. Our pilot deployment suggests that it can improve overall workplace awareness and provides insights into how the use of an awareness tool is affected by its own availability.

Recent work has investigated privacy concerns related to the use of context-sharing systems. Lederer et al. [17] found that the situation's specifics and to whom the information would be available affected users' decisions on what information to share. Brush et al. [5] focused on users' concerns about where information was presented. While they found no overall effect, they did find differences among users for the information they would allow to be reported by an awareness system. Our work addresses users' varied privacy concerns as a factor for user acceptance. Direct user control over information collected and shared was an important consideration for myUnity.

Systems for Supporting Communication and Awareness

A number of existing systems support awareness in the workplace. Most provide a single-channel of information. For example, shared calendars allow workers to be aware of others' scheduled activities. Chat and instant messaging software often relay whether or not a contact is using his computer. Tracking systems that use ultrasonic, active RFID, or other RF technologies (e.g., [29]) can determine a worker's location in a building. Video systems, like Port-holes [7], allow workers to directly observe the state and activity of others. While all of these provide some level of awareness, a narrow, single channel of information often falls short of providing sufficient information to facilitate many common communications needs, leaving users to combine information from these sources on their own, often unreliably and with costs in time and effort.

Sideshow [6], Community Bar [18], MyVine [12], and ConNexus [26] collected some awareness information, such as IM status and calendar, into a side bar interface on the desktop. Awarenex [26], ContextContacts [20] and Connecto [2] are all mobile awareness systems with various representations of location and other data, such as calendar information, ring tone profile, and Bluetooth neighbors. These systems were all either specific to mobile or desktop environments, and do not represent a complete solution for

users. As our findings demonstrate, combining desktop and mobile platforms provides important benefits for collecting awareness data and for presenting this information to users.

While most awareness tools tend to focus only on providing information, not helping users translate the information into action (e.g., initiate a communication), some systems do exist that serve this function. Cruiser [10] presents users with short, symmetric glimpses into co-workers offices to simulate the effect of walking down a hall of open office doors. Quiet Calls [19] enabled the receiver of a mobile phone call to respond by using buttons to trigger pre-recorded messages to the caller. Calls.calm [21] allows both caller and receiver to express details of their situations and desire to communicate explicitly at the time of initial contact. The Negotiator [30] system helps two users negotiate an agreeable time to hold a phone call. What is important to note is that these tools require users to explicitly and regularly provide information about themselves.

While individual components of awareness systems have been examined, breakdowns remain due to the lack of integration across resources, making it difficult to find the information in a manner appropriate to the situation. Our goal with myUnity was to extend the value of both awareness and communication-initiation tools by bringing them together into a single, integrated platform. The result is a platform with two important components: (1) it is largely automated, requiring little user attention to produce a rich set of information, and (2) it is comprehensive, enabling users to easily access previously disparate information, and translate that information into informed action.

Studies of Awareness Technology

Past work has shown the value of context-enhanced communication tools. For instance, Hsieh et al. [15] studied context-enhanced IM and showed that the added context about location and a model of interruptability were both appropriate and useful in negotiating communications. Similarly, evaluations of sensor-based models of interruptability (e.g., [1, 11]) have shown that certain environmental cues are more meaningful than others for deducing others' activity. This work informed our selection of sensors and the information they report.

Studies of awareness systems have been performed, but the research is fairly limited. Romero et al. [23] studied Community Bar in university settings and found that many of the theoretical design assumption were incorrect. For instance, implicit actions were made explicit, often too much so, in the system's representation of the awareness state. Szorstek et al.'s study [25], also situated at a university, found that visualizing availability alone is not enough; awareness tools also need to be reciprocal and users need to be accountable for the information represented. We incorporate lessons learned from these studies into our platform's design. For example, the recommendation on accountability [25] influenced how myUnity negotiates uncertainty. Synthesizing past results with our own helps to advance awareness tool design. Our contribution is especially meaningful in informing the design of technologies that provide a combined desktop and mobile experience.

WORKPLACE COMMUNICATION AND AWARENESS

Past work provides a solid foundation for understanding communication and awareness needs in the workplace. However, much of this work studies a workplace that may no longer be contemporary. For instance, the emergence of mobile devices has profoundly shaped how we go about our day-to-day work. Therefore, we performed a study of workplace communication practice that seeks to build on the foundation of past findings but with insights reflective of modern practice. Based on this goal, we choose to take a broad approach to understanding the wide-ranging communication methods workers employ as well as the current technologies workers use to support those methods.

Method

We conducted 12 interviews (30-45 minutes each) with professionals in sales, medical innovation, software development, security products, and research. We recruited using an online ad (n=3), through existing relationships with external organizations (n=5), and from our own organization (n=4). We chose a diverse population to build an understanding of a variety of work practices and to identify breakdowns across multiple contexts. We asked participants about their communications practices: how they contacted co-workers and how co-workers contacted them. Participants described both general strategies and specific situations. By eliciting these retrospective accounts of real experiences, the interviews were grounded in concrete situations rather than idealized abstractions [4].

Findings

While we found that successful communication does occur, we also found a wealth of evidence that suggested existing resources fail to support the needs of the modern workplace. These failures led to a set of design requirements, which we have included for each problem identified.

Problem Observed: *Communication is driven by interaction and information need, not time and place.*

All interviewees reported working outside the office — working entire days at home or at remote sites, replying to emails on their phone while waiting for their kids, or getting up early to take calls from geographically distant peers. These experiences, even for those who described their jobs as “not time-critical” or who had little required travel, suggest that their work is not defined by a physical space or traditional hours of a work day. As one said, “*I talk to our people, at least the key people, my direct reports ... three times a day ... regardless of where in the world I am. And that kind of tells you how important it is for me to communicate with them.*”

Functional Requirement 1 (R1): *Awareness information must be accessible always, and across multiple platforms.*

Our findings suggest that awareness information must be accessible ubiquitously to meet the needs of emerging work styles. Systems must support multiple platforms to fit the various environments that exist in modern work practice. Also, information about colleagues should be available at all times, as our interviews uncovered many situations where awareness information is just as useful (if not more so) outside of normal working hours.

Problem Observed: *Channel choice can convey conflicting or wrong indicators of channel preference and immediacy.*

Nearly all participants expressed frustration in the fact that choice of a communication channel conveyed both an indicator of immediacy as well as preference. Phone calls are common examples of this. A person who wants to have a verbal conversation, but who doesn’t need to have the conversation immediately may decide to make a call to satisfy the *preference* constraint but may misrepresent the *immediacy* constraint. Alternatively, if the person needed to discuss an issue right away, she may choose to use the phone because it will interrupt and get the caller’s attention. This satisfies the *immediacy* constraint, but misrepresents the *preference* constraint.

Participants recounted a number of examples of preference/immediacy conflicts. They varied from feeling obligated to take phone calls from bosses while in a meeting with customers to frustration in having to communicate technical details on a lossy channel. The latter is well illustrated by this comment from a support engineer trying to contact a non-responsive product engineer: “*[he didn’t respond to email] several times last week ... as well as this morning, so I basically [have to] call this colleague of mine on his cell phone, because that is the best way with him.*”

R2 Tools should allow preference and immediacy constraints to be expressed independently and explicitly.

These findings suggest that communication tools need facilities that allow a user to communicate intent and channel preference independent of the channel itself. For instance, a user wanting to have a verbal conversation should not also be forced to interrupt the callee, especially if the current activity and state of that person is unknown or unclear. Yet, the current state-of-the-art provides little to no support for effective negotiation of communication intent. Today, the situation just described usually ends in the caller having to resort or default to a less preferred medium, for instance email, to either conduct the conversation or to simply negotiate an alternative time and/or medium. Providing simple, out-of-band negotiations could all but eliminate the preference/immediacy overload.

Problem Observed: *It is difficult for individuals to convey how they prefer to be contacted.*

Related to the previous problem, our investigation found that individuals seldom get the opportunity to express their preferences for receiving a communication. For instance, there is little feedback a user can give to indicate that a phone call is not appropriate at a given time, or that she generally prefers instant messaging for quick, non-time-critical conversations. Some tools have facilities to express preference; for instance, many instant messaging systems allow users to update their status messages. However, it can be burdensome to do these manual updates, resulting in increasingly out-of-date information.

R3: Systems should allow users to flexibly and dynamically express their preferences for being contacted.

Participants expressed several dynamic factors that they consider relevant when receiving a communication. Many illustrate the need for better support:

- *Situational factors limiting a channel's availability or acceptability.* A common example of this was wanting colleagues to be aware of being in a meeting with clients.
- *Personal preferences for specific channels.* Preferences varied by participant and were well-articulated. Some preferred that all interactions be face-to-face and were willing to travel or postpone communication to achieve this. Others preferred email or other asynchronous channels, even when face-to-face interactions were easy. Many wanted to make these preferences more explicit.
- *Defer or redirect to an alternative channel.* Participants described situations where particular channels would be impossible (e.g., email while driving) or inappropriate (e.g., phone while in a meeting) to use for a communication event. In these cases, they wanted an easy way to redirect the communication to a different channel (e.g., redirecting an email thread to text-to-speech on a phone while driving, or sending SMS chat messages “under the table” while in a meeting).

While these may seem obvious, it is surprising that many existing communication tools provide little support for these preferences. R3 also illustrates an interesting tension between the desire for expressiveness and communication choice and the need for solutions that integrate or cooperate in functionality. It is perhaps this lack of flexibility that has hindered the adoption of past awareness technologies.

Problem Observed: *Existing awareness tools are limited, unreliable, and infrequently used.*

Many participants reported trying to use awareness cues from personal and corporate calendars as well as IM status with limited success. Interviewees reported that these awareness cues provided low-fidelity or inaccurate data. One interviewee reported sending IMs to individuals whose IM status was “present” but who were in fact not present at all. Others reported that calendar information was rarely comprehensive as the ad hoc, unplanned collaborations that are common in most workplaces were usually not included.

The incompleteness and inaccuracy of these systems lead to decreased use. Generally interviewees attempted to initiate a communication without consulting these resources, only later to learn or remember that information was available elsewhere. One interviewee recalled making a phone call to a colleague who was in an important meeting that the caller should have known about. He had access to the calendar, but he forgot to check when he made the call, resulting in an embarrassing interruption.

R4: *Awareness information should be complete and convey relevant information from the many channels users employ.*

Our interviews indicated that the available awareness information was often incomplete. Frequently a colleague's physical location was missing. This was especially important for those who worked less-traditional hours or often worked outside the office. In other cases, the issue was not access to the information, but having it in a useful format. Participants frequently forgot to check information to which they had access, particularly if it had to be accessed through multiple sources. Accessing awareness informa-

tion should not require the use of multiple tools or artifacts (e.g., checking a calendar in one application and IM status in another). Unifying this information in a single place is essential. Providing the means to initiate a communication efficiently from that place enables users to act on the awareness information.

Problem Observed: *Many users struggle with the tension between “being present” and “being connected”.*

Participants were concerned that receiving communications (e.g., phone calls, email) when already engaged in an activity, particularly during meetings and presentations, detracted from their engagement. Explicit attempts to avoid these distractions were viewed as unacceptable, since some of these communications might be urgent. However, existing strategies to mitigate this issue were also found to be undesirable. For instance, to determine if an email is urgent, it has to be opened and partially read. It is worse for a phone call, as it often must be answered to determine its context. One interviewee explained his own battle with this tension: “*I think we’ve got to the point where we’re too reliant on these [Blackberrys] in meetings ... it takes away some of the focus. I’m guilty of it just like everybody else, but I’m trying now to start leaving this out of meetings that I need to pay a greater attention to.*”

R5: *Awareness systems should serve as a filter to minimize interruptions, shifting the burden from contactee to contactor.*

If users know that their awareness information is easily accessible to those who initiate communication with them, they can be more purposeful with their communication. The need to constantly check one's phone for important emails during a meeting will be made all but unnecessary if communication media are augmented to support the varying needs of all parties involved in the communication.

THE MYUNITY PLATFORM

myUnity is a contemporary platform designed to support the myriad of awareness and communication needs of the modern work environment. Below we describe the major components of the platform: client applications, sensor and data aggregators, and central server.

Client Applications

The client applications provide users with quick access to several channels of awareness information. Additionally, the client provides facilities that assist in coordinating communication with peers. We developed both mobile and desktop clients in support of R1. Below we discuss the three main features of myUnity: the awareness dashboard, individual detail views, and structured interactions.

Awareness Dashboard

Figure 1 shows the dashboard (the main visual display) for the desktop and mobile clients. The dashboard features an array of photo tiles, each representing an individual in the organization. The border color of the tile reflects the individual's current presence state. We chose colors following several prototype iterations in which we varied features like saturation. The results clearly showed that consistency of color and meaning across devices was the most important factor. The color palette indicates a person's presence:



Figure 1. myUnity platform clients. Tile colors are consistent across clients, including on the desktop dashboard (left), and the mobile dashboard (right). The desktop dashboard displays location from on-phone localization (A), or Bluetooth/Wi-Fi infrastructure (C), and calendar information (B). In addition, the detail views for the mobile client (far right) and desktop (over dashboard) show presence data (D), status messages (E), contact information (F), and IM client status (G).

- Green** physically in office, alone
- Purple** in office with at least one other person
- Yellow** in office building, but not in office
- Blue** using computer from remote location (not office)
- Orange** on mobile client only, not in office building
- Grey** system has no current information

While it may appear overwhelming at first glance, participants in our user study found the colors to be easy to remember in practice even after limited use.

The desktop dashboard is configurable. As the number of pixels for the application window increases, the tile size expands and can include additional information (e.g., full name, a description of presence state, and calendar data). Users can choose to represent individual tiles in one of three sizes, allowing users to customize the visual representation to maximize the awareness details about specific individuals while minimizing details of others.

The dashboard allows users to know the presence state of their colleagues at a glance. With quick access to presence states users can efficiently acquire information useful in determining a channel and time to communicate with a colleague, supporting R2. For instance, one could quickly confirm that a peer is in his office alone before initiating a phone call or physically walking to his office.

Individual Detail Views

In both interfaces, selecting a person's tile provides additional information about that person. This detailed view (see Figure 1), provides the person's presence information, approximate location (for those who allow myUnity to determine their location), current status message, and links to phone numbers, IM, and email, supporting R2, R4, and R5. Clicking on a link launches the appropriate interface to directly communicate over that channel. Only those channels enabled by the recipient can be selected.

Structured Interactions and Messages

While awareness of a person's state is helpful in many situations, even a system that is always on and always correct will not enable users to share information about particular situations (R3), nor does it facilitate expression of channel preference and immediacy (R2). To support these needs myUnity provides the Nudge, Ping, and Status Messages.

Nudge provides a template for lightweight negotiation of channel and time for communications. It allows users to separate immediacy and channel preference from the communication itself. A nudge is a four-step process, two steps each for the contact initiator and the recipient:

1. The initiator selects preferred and acceptable channels, and the time frame for this communication to take place.
2. The recipient gets a message (Figure 2, left) with the initiator's information from step 1. The recipient specifies if he can communicate within the initiator's timeline and his own time preference within that timeline. In addition, he selects which of the proposed communication channels is preferred at each time.
3. The initiator sees the options provided by the recipient and can make a final selection or cancel the Nudge.
4. The recipient receives a final confirmation.

Although some of the functionality provided by the Nudge exists in other tools or practices, it differs from them in that its interaction is designed to help initiator *and* recipient converge quickly on an agreed-upon time and channel. Further, a successful Nudge depends only on the participation of the initiator and recipient during the Nudge interaction. This differs from other tools that require users to keep calendars or a precisely up-to-date set of rules.

Ping (Figure 2, right) provides a template that allows people to send a short, predefined message to another user, along with their awareness information. Unlike the Nudge,

the Ping does not facilitate back-and-forth communication. It is designed to provide a simple heads-up to others. For instance, a user can send a Ping with the message “running late” along with automatically collected location information that could enable the recipient to understand how late the initiator is likely to be, without the initiator having to articulate it directly. A ping can be thought of as a structured, contextual SMS that requires fewer clicks to communicate much richer and up-to-date information.

Status messages provide a simple way to supplement the automatically collected data with details about their current state. Status message content is not restricted, but their length is short. Examples include: “hosting visitors today,” “working on a paper deadline,” and “working with customers off-site.” These messages appear in a window on the desktop dashboard and on individual detail views.

Mobile Client

As shown in Figures 1 and 2, the mobile client provides the same awareness and communication options as the desktop client. This enables our users to stay in touch with co-workers while they are away from the office (supporting R1). At the same time, the mobile client can provide information about the user’s location and phone call status (supporting R4). The mobile client uses a background service to periodically determine the location and to upload it to the server.

Battery consumption is a very important consideration for the acceptance of mobile applications. Our first version used GPS to determine accurate locations. Unfortunately, that approach used so much battery capacity that the phone would not last a day on a single charge. In contrast, calculating location based on Wi-Fi and the mobile network does not deplete the battery excessively. However, even after reducing the frequency of network access, the mobile client still consumed too much energy for some of our users.

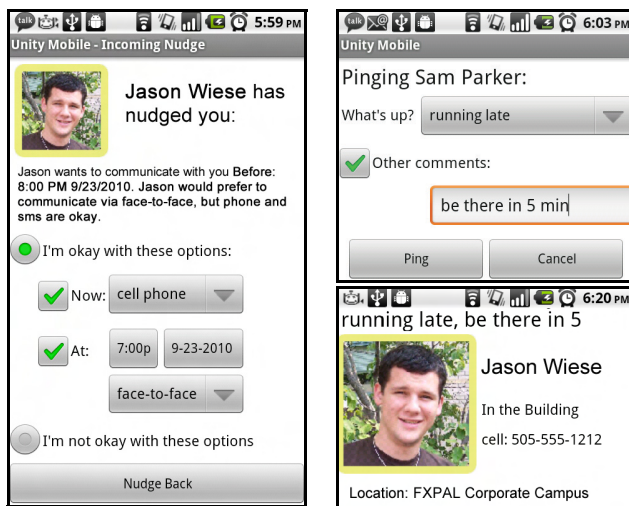


Figure 2. Nudge (left) and Ping (right) on the mobile client. The Nudge forwards information about the communication request to the recipient and asks him to share his availability. The Ping interface shows what it looks like to initiate a Ping (top right) and to receive one (bottom right).

A second redesign addressed this issue. In this iteration, the phone only needs to be awake a few seconds in every five minute interval. During that time, the client schedules location updates, uploads its data to the server, retrieves data for all other users, and then allows the phone to go back to sleep. All data from the server are compressed to reduce transfer times. With these improvements, all users reported having their phone’s charge last at least until the end of the day and frequently for two days in a row. This experience demonstrates the importance of optimizing battery use for real-world deployments of mobile applications.

Sensors and External Data Aggregators

myUnity collects information from a bank of independent sensors and external data aggregators for presentation in the application clients. Our aggregator architecture is component-based, allowing channels of awareness information to be added, updated, or removed at any time. We implemented six aggregators for the platform, which provide the core awareness information that we found to be essential to support communication and awareness in the workplace, and combine them to support achievement of R4:

- *Vision-based office activity.* Using a video feed from a small wide-angle camera (mounted in the corner of personal offices), users can specify the physical space of their office that they typically occupy and the space occupied by visitors. When motion is detected in these spaces, an appropriate state is reported. Raw video is not shared.
- *Mobile phone location.* In addition to the mobile client reporting location (discussed above), Bluetooth and Wi-Fi access points installed throughout the office can trilaterate the signal of a user’s phone or other wireless device to provide a user’s physical location within the building.
- *Computer and network location software client.* The desktop client can report when a user is actively using the computer by detecting mouse and keyboard activity. It also reports the network address of the connection (inside a corporate network, remotely on VPN, or external).
- *Calendar.* Users can link information from various calendaring systems. This includes information from corporate calendars (e.g., vacation, sick, or travel day) and personal calendars (e.g., personal and professional meetings).
- *IM presence.* Users can report their status from IM protocols (e.g., Jabber, Google Talk, Skype, and Windows Live Messenger) by supplying their username.
- *Phone call status.* The mobile client and the IP-based office phones can report whether or not they are in a call.

An important design characteristic of the myUnity aggregators is that users can independently select which ones report information on their behalf. Thus, people can customize myUnity’s data collection to conform to their own privacy concerns and requirements. This aspect of the architecture is different from most existing systems (e.g., [16, 24]) that control how data are *disseminated*, not *collected*.

Central Server

The central server is responsible for collecting information provided by the aggregators, fusing and summarizing this

information, and streaming the result to client instances. myUnity takes a slightly different approach to fusion and summarization in that it does not infer or predict state (as is done by other systems), but rather degrades the data's resolution to convey only what it knows to be true, an important feature for supporting R4. For example, if it receives data that a user is present in the building and is logged on to several IM protocols but no evidence from her office activity sensors, it will not infer that she is in her office, only that she is in the building. While degrading the state may produce less useful results, it avoids situations where the system is incorrect. It also helps users to understand how the data collected about them are presented to their peers.

PILOT FIELD DEPLOYMENT

Based on myUnity's design goals, we felt it was important to evaluate how the combined use of the mobile and desktop platforms impacted collaborative practice. As noted in the Related Work section, we believe myUnity is the first complete system that encompasses *sensing* and *access* across mobile and desktop environments. Understanding the impact of this approach is likely to have significant value for the design of future awareness technologies. In this 4-week pilot, we sought to understand how the various features of our multi-platform design were used, how use of specific features and/or platforms impacted perceived value, and how the differences in use impacted overall awareness and communication practice.

Participants

In our interviews we identified various users and organizations that motivate the need for improved awareness technology. However, we chose to study the use of myUnity within a single population to reduce confounding the results with specific domain or workplace influences. We further wanted to choose a population where use of myUnity was not imposed by a mandate. That is, we did not want participants to be forced or even encouraged to participate by those that evaluate or manage their work. As such, we recruited 29 participants from within our larger organization through direct, internal study solicitations.

Participants exhibited many of the characteristics embodied by our design lessons. Specifically, the organization's work policy allows workers to perform their responsibilities outside the office. An average of 4.96 (sd=1.91), participants (~18%) worked outside the office on each of the 22 weekdays of the study, which is in line with reports by modern workplace studies. Participant professions included research scientists, software developers, administrative/support staff, executives, and several specialists.

Groups

Motivated by our desire to understand the impact of our combined mobile and desktop platform, we partitioned participants into four groups that varied the participants' "connectedness" into the platform. Specifically, groups 1 (n=8) and 2 (n=7) had the myUnity desktop client installed on their office computers and the mobile myUnity client installed on an Android phone. Group 1 participants also had a 3G data plan. Group 2's phones could only access data when a Wi-Fi network was available. Both groups had

access to Wi-Fi throughout their workplace and at their homes. In a sense, Group 2 represented the connectedness of PDA or Wi-Fi-only tablet users. Group 3 (n=8) had the desktop client installed on their computers but did not have the mobile client. Group 3 represented the common configuration used in previous awareness systems. Group 4 (n=6) was a control and did not have any access to myUnity. It is important to note that group assignments were not based on prior experience or use with smartphones. For instance, all but one member of Group 3 were avid Apple iPhone users; the seventh used an HTC Photon (Windows Mobile 6.5).

We gave each participant in groups 1, 2, and 3 an introduction to the myUnity clients to familiarize them with their features and to demonstrate configuring preferences. Participants were asked to use myUnity to assist in day-to-day communications when they felt using the platform would be helpful. All participants knew about myUnity; however, none had used the version deployed in the study.

Data collection

We collected several different kinds of data. All interactions with myUnity were captured: when the dashboard was open, when individual awareness information was shown, and when communication was initiated from within the client (e.g., sending a Ping or placing a phone call). We also administered pre- and post-study questionnaires. We asked each participant their process for initiating communication with colleagues and the factors affecting this process. The questionnaires also included a modified subjective awareness rating test (SART [27]). Lastly, we conducted a 30-minute interview to understand their use of myUnity.

Results

Measures of Use Across Groups and Platforms

During the study, participants had 27,901 individual interactions with the system (15,986 desktop, 11,915 mobile). We grouped these into 3865 *sessions* (2,251 desktop, 1,614 mobile), defined as a group of interactions during which no consecutive interactions were more than 60 seconds apart.

Group 1 had the highest overall use across both platforms, followed by Groups 2 and 3 (Figure 3) as measured by the number of sessions per day ($X^2_{(2)}=1068.19$, $p<0.001$; Group 1: mean=4.69, sd=6.69; Group 2: mean=2.84, sd 4.41; Group 3: mean=2.64, sd=4.13). Results show that Groups 1 and 2's use of the mobile client did not appear to reduce their use of the desktop client. During off hours (before 9:00, after 18:00, and weekends) use was much greater for Group 1 compared to other groups (desktop: $X^2_{(2)}=43.13$, $p<0.001$; mobile: $X^2_{(1)}=26.59$, $p<0.001$). This likely reflects the utilization of Group 1's ubiquitous network connectivity and resulting fulfillment of R1.

Interestingly, the groups also differed in the number of interactions per session. The difference was significant, with Group 1 having more complex interactions than Groups 2 and 3 ($F_{(2,17)}=3.70$, $p<0.05$). On average, Group 1 had 35% more interactions per session than Group 2 and 31% more than Group 3. Thus, use of myUnity was not just more frequent, but also more interactive for Group 1.

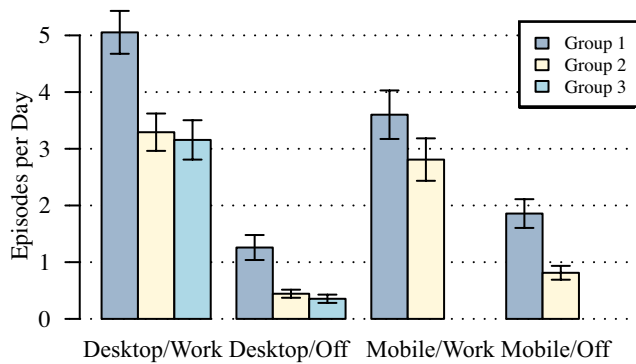


Figure 3. Episodes per day during work and off hours for desktop and mobile client. Group 3 used the desktop only.

Through the course of the study, participants sent 52 Nudges and 99 Pings, with 14 and 27, respectively, sent from the mobile client. Adoption was slow, with the majority of Pings and Nudges being sent in the final days of the study. As we found in our interviews, many participants indicated it was hard to break normal communication habits, even when awareness was enhanced through myUnity. For instance, many felt compelled to still send email to determine a meeting time, rather than using a Nudge. However, several participants commented that there was great potential in the Ping and Nudges, as one user stated he's *"starting to get into the Nudge, but it requires a behavior change. It's not something you can get into overnight."*

User Ratings and Feedback

We asked participants in Groups 1, 2, and 3 to rate the value of myUnity on a 1-7 Likert scale, where 1 was "it provides no value to me" and 7 was "it is very valuable to me." Ratings across all 3 groups were positive, with no significant difference between groups. Most participants (87%) rated the platform as 4 or better. Most (91%) indicated they wanted to continue using myUnity.

We also asked participants in Groups 1 and 2 to rate each client individually. Results showed no significant difference for the desktop client (Group 1: 5.38, Group 2: 5.29). Group 1 rated the mobile client generally higher than Group 2 did, although the difference did not reach significance ($t(12.7)=1.48$, $p<0.2$, Group 1: 4.312, Group 2: 3.43).

Users rated the importance of individual features provided by the platform. Ratings were consistent across groups, with no significant differences. The *presence state* was rated highest (mean=5.8, $sd=1.3$). The *location* (on campus, at home, in specific city/state) and *calendar* (on vacation, in scheduled meeting) features were also rated highly (mean=5.0, $sd=1.3$ and mean=5.3, $sd=1.3$, respectively). Less important features were *IM status* (mean=3.5, $sd=1.9$) and *status messages* (mean=3.6, $sd=1.7$). Interestingly, myUnity's two highest rated features are those not offered by current, state-of-the-art tools. Also of interest is that nearly all features were found valuable, supporting the value of the system's comprehensiveness (R4).

The Situational Awareness Rating Technique (SART) was also administered (see [27] for details on SART) to all groups before and after the study. Wilcoxon paired, signed-

ranking test showed no significant difference in the overall SA-scores, though scores trended toward increased awareness for all groups. In addition, Group 1 had significant individual SART measures with an average 16.3% increase ($sd=21.59$) in the quality of information available ($Z=-2.10$, $p<0.05$) and a 22.9% ($sd=25.7$) decrease in the total amount of information necessary to build SA ($Z=-2.10$, $p<0.05$).

Interestingly, participants that rated myUnity as a 4 or better, had a significant increase in their overall SA score ($Z=-1.94$, $p<0.05$). Those who rated the platform lower than 4 exhibited no significant change. These results suggest that, even over a period of 4 weeks, there seems to be a positive relationship between the value users place on the platform and an overall improvement in situational awareness.

Qualitatively, most participants (19 of 23) reported that the increased awareness provided by myUnity led to changes in how they initiate communication; for instance, checking myUnity to see if colleagues were in and without visitors before going to talk to them (87%). As one user said: it *"tells where a person is, if here or not. I don't need to make wasted trips."* Many also reported using the clients to find phone numbers, initiate phone calls and IMs, Nudge someone to negotiate communication, or Ping with a quick alert of state, demonstrating how myUnity satisfies R2 and R3.

As noted in the data above, Group 1 participants exhibited longer use sessions. The interviews provided insights into the context of these *complex* uses of the tool. For example, one Group 1 participant described using myUnity to decide whether to return to work or work from home, depending on who was in the office. Another example demonstrated using multiple features of myUnity together, using it to see if people were in, then sending a Nudge rather than walking over and potentially causing an unwanted interruption. We feel these particular uses of myUnity not only further illustrate R2 and R3, but also provide some evidence of how myUnity's design was starting to satisfy R5.

Finally, we also wanted to gauge participants' privacy concerns. Overall, Groups 1 and 2 had higher concerns over privacy than Group 3. Thirty-five percent of Group 1 and 2 participants expressed some (mostly mild) concerns. One participant explained not wanting to be *"tracked when I'm not at work."* She continued, *"I know I can turn it off but it's easier to just not carry it."* Another said it was *"creepy that everyone knows where you are."* No participant indicated concerns high enough to stop using myUnity.

DISCUSSION

Through the process of designing, prototyping, and performing an initial evaluation of our platform, combined with the interviews we conducted and functional requirements we developed, we have gained key insights that can inform future research on awareness tools and platforms.

The Whole Is Greater Than The Sum Of The Parts

Past awareness technologies have concentrated on providing access to information in one place (e.g., desktop or mobile). Our findings reflect that people found meaningful value in having awareness information that is *always easily accessible* across the variety of places, situations, and con-

texts in which users live their lives, just as we identified in R1. Evidence of this conclusion manifests in two ways.

First, our system aggregates data from multiple sources. It can collect data (at the user's discretion) from any device that is running the client. This flexible approach supports varying levels of adoption and resolution of information. For example, a mobile system alone cannot easily determine if you are at your desk in the office, let alone whether anybody else is also there. Similarly, a system without mobile support may be able to recognize that you are not in the office, but it could not inform peers that you are actually just two buildings over. Systems with less flexible approaches often mislead users, violating R4. A pervasive platform approach provides richer awareness information, whose granularities are less dependent on the technical constraints of any single approach.

Second, the always-accessible nature of this information is critical. At first glance, this would seem to support an argument for a mobile-only client, which one could claim is always accessible. However, our findings indicate otherwise: usage of the mobile client did not replace usage of the desktop client. Although mobile affords the same functionality, participants generally had a preference to use the desktop if both were available. At the same time, mobile had distinct value in situations where the desktop is inaccessible or inconvenient. This was key in supporting R1: ensuring awareness information is always easily accessible.

Level of Use Is Tied To Attributed Value

One clear observation was the varied sophistication in how users explained their use of myUnity. High-use users were very articulate about how different features of myUnity were used to support their communication practice, as exemplified by comments from one high-use participant: *"I use a Nudge instead of walking to office and possibly interrupting them. It's good for when you feel like email is too slow but face-to-face too interruptive."* In contrast, low-use users were less descriptive. As one stated *"it helps me manage if I'm going to go bother someone."*

What is clear from these quotes and the results centered on explaining complexity of use is that differences exist in how users leveraged myUnity to gain awareness of peers and translate that understanding into meaningful actions. Some formulate loose dependencies, while others have developed more complex patterns of application and use. This has several implications for future awareness tools. First, it demonstrates that supporting different levels of participation is important for increasing overall platform use. Awareness systems that support R1 will address this. Second, technology adoption is seldom universal, often because people do not see value in it for themselves, thus limiting the overall value of systems by hindering critical mass. By allowing varying levels of participation, myUnity enables individuals to contribute to the value of the system with little effort, even if they do not find value in it themselves. This enables the system to fulfill R4 and present complete, accurate information. As the research on awareness tools matures, researchers will need to pay greater attention to mediating these individual differences.

Not All Awareness Information Is Created Equal

By having a functional prototype to experience all the features, users were able to meaningfully gauge the overall importance of each. Interestingly, two rationales for their valuation emerged, both of which support R3.

First, features were perceived to be important if they were automated or if manual updates were believed to occur regularly. This provides additional support for the importance of R4. For instance, users reported making communication decisions based on someone's presence in her office or on her calendar availability. On the other hand, status messages were not seen as being representative of current state, and were judged to be less reliable.

Similarly, users attributed high value to those features that clearly conveyed communication accessibility. For instance, knowing someone is present and alone in his office can be easily interpreted as being accessible for face-to-face communication. However, IM status was seen as less descriptive, as being "online" did not relay location or accessibility, even within the IM channel itself (e.g., online, but away from one's desk). This provides further support for the necessity of both R3 and R1: awareness systems must be cross-platform and provide awareness of channel preference. To the extent that the system satisfies these goals, support exists for R5 by also helping to shift the burden of communication from contactor to contactee.

It is important to note the high-value features, and their specific characteristics, are those commonly not supported in the state-of-the-art communication tools. As a result, we are optimistic about the potential to improve the landscape of communication tools through new and complimentary tools, like myUnity, which provide these features.

The Promise Of Negotiating Communication

While a majority of our participants used the Ping and Nudge features, the overall low quantity of Nudge and Ping interactions illustrates how new technologies and paradigms can take a while to gain traction. Nonetheless, our study allowed us to better understand how they fit into the available features of awareness technologies. Feedback indicates that the lack of universal access to Ping and Nudge reduces their value. For instance, Nudging somebody in her office is perhaps less valuable if you can just drop in. If she is not in her office and does not have a mobile, there is little value in sending a Nudge. The value was clearest when both initiator and receiver were able to negotiate independent of device and/or network limitations, a result that emphasizes the importance of R1.

Participants still used traditional negotiating strategies with people they interacted with outside the local organization, including peers elsewhere in the corporation. This presents a clear opportunity to extend the system, by interfacing it with existing communication channels to enable its users to carry out *all* their communication negotiations through Nudges and Pings, supporting R5. Passing awareness information on those channels would also enable individuals to be as considerate as they would like to be when initiating communication, supporting R2.

CONCLUSION AND FUTURE WORK

The workplace is changing rapidly to one that is less predictable and more dynamic. While technological advances enable this new workplace, there are clear shortcomings in existing solutions. myUnity combats these shortcomings by providing: (1) convenient and universal access to awareness information, (2) automated collection of a wide variety of awareness information, and (3) facilities to express preferences that are otherwise not communicated. Our results demonstrate the platform's value, and the necessity of each component for affecting positive change.

Our results serve as inspiration for several future activities. First, we intend to study the platform in organizations with different properties (size, hierarchy, mobility) and over a longer duration. We also plan further exploration of how the platform could be adapted to allow non-users limited access through conventional communication channels, and how we might support multi-party negotiation. Finally, in this new workplace, it will be harder than ever to partition personal and professional communication. Future work will examine servicing both professional *and* personal needs.

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