

# Current Perspectives on Awareness Information to Support Real-Time Communication

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**Abstract**—Sharing awareness information to help remote people establish real-time communication has been a research area for the past couple decades. Much of the work so far has focused on sharing awareness for communication availability in the work setting. Yet several recent trends suggest the need to reconsider the contexts and assumptions around awareness research. Increasing deployment of communication technology in homes and the blurring of home and work boundaries means that more communication interactions involve the home. The popularity of mobile smartphones adds the mobile context and the sensor capabilities integrated into mobile devices. Given the broadened scope of where and how communication occurs and the importance of being able to smoothly negotiate starting and ending conversations, there is an opportunity to reconsider awareness research in today's environment. We identify current challenges and opportunities in awareness research from perspectives beyond focusing just on the workplace to include technologies and use practices in the home and mobile contexts.

**Keywords**—awareness; availability; presence; awareness; computer-mediated communication; workplace; home; mobile

## I. RECONSIDERING AWARENESS INFORMATION

For the past couple decades, research on presence and awareness has explored how to help people time and negotiate their attempts to establish communication over distance. Yet during the course of those years, much of the technology and use practice landscape has changed in ways that have a direct impact on how people use and interpret awareness information. The increased use of computer-mediated communication (CMC) in the home adds a distinctly different context in which to establish communication. The growing popularity of mobile smartphones not only adds a mobile context for establishing communication, but also offers new sensing capabilities that increases the amount of awareness information available. In light of these recent developments, we identify several important dimensions for reconsidering awareness information to support real-time communication.

### A. Awareness in the Workplace Context

Much of the prior awareness research has focused on work-based communication, typically in the office setting of a work environment. For example, the early Media Space work [1]

shared always on video and audio connections across remote sites to naturally share the cues that people use to start and end conversations. Pedersen and Sokoler [2] explored less literal and more abstract representations of remote presence, and even pointed to the need to go beyond work to social communication in general. Tang [3] summarized a progression of techniques aimed at helping work colleagues use awareness information to negotiate starting and ending real-time communication.

Hudson et al. [4] conducted an Experience Sampling Method study to identify what are the strongest indicators for availability in the workplace. They concluded that the presence of speech (i.e., that a person was already engaged in conversation with someone else) was strongly correlated with being unavailable for new interaction. Sophisticated models for predicting presence and availability based on on-line calendar and computer activity information that is readily available have also been developed in the work context [5], [6].

More recently, Dugan et al. [7] integrated data from a number of workplace tools to generate a visualization of how people spent their time at work. This exercise identified that the biggest challenge is to capture accurate time-based data from the range of different tools used in the workplace. This challenge would also apply to collecting data regarding awareness and availability. They also found personal differences in interpreting the meaning of how they spent their time at work.

Birnholtz et al. [8] studied the effects of reciprocity in sharing awareness information. In face-to-face interaction, I am reciprocally aware of when you are monitoring me to see when I am available for an interaction. That reciprocity is typically lost in remote interaction, and they studied whether that affects how often one checks on a remote person's awareness information. Their results suggest that people check more often when they believe their partners do not know they are checking. This finding suggest that checking awareness information is governed by some privacy concerns that are relaxed when there is not reciprocal awareness of checking on availability information.

Sharing awareness in the workplace can leverage many resources and conditions that are typical of a work environment. The traditionally higher performance computing

and networking equipment available in the workplace reflects the willingness to invest resources in productivity at work. People at work in offices are often assumed to be alone, sitting in front of a computer, and using it for sustained periods of time. Office workers tend to have rather predictable work hours which may be largely governed by an online calendar. Furthermore, co-workers in the office belong to a shared organizational culture where people are expected to be available for each other's work-related needs and have shared access to many of each other's work resources.

### B. Awareness in the Home Context

Research has also begun to look at the home environment as a different context for using awareness to coordinate communication. Hindus et al. [7] explored what a Media Space in the home might look like, leading to more abstract and less media-rich prototypes that indicated when remote people were available and allowed them to exchange messages and scanned artifacts. These prototypes reflected the different needs for social connection in the home. Tollmar and Persson [10] designed a range of ambient prototypes in the home that gave more of a background sense of maintaining social connectedness across distance. Neustaedter et al. [11] identified a few different social clusters to interact with at home and the different levels of information detail needed to coordinate with them. They characterize interpersonal awareness as less focused on tasks and more oriented around coordination of everyday activities.

Nagel et al. [12] investigated predictors of availability in the home using an Experience Sampling Method, as they expected those predictors would be different in the home than what prior research found in the workplace. They found considerable individual differences in correlations with availability, which perhaps reflects greater diversity than would be found in the workplace. In contrast to the workplace, people at home were less likely to be available when alone. Being in and around the kitchen offered the highest likelihood of being available, and they found correlations with specific activities (e.g., watching TV, playing games) with availability. Notably, the presence of speech in the home was not such a strong predictor of unavailability, as it was in the office. It is interesting to note how their findings of availability at home differed from availability at work found in previous research.

The home offers different cues of activity and requires different interpretations for availability. Plus, users in the home are not typically sitting in front of a computer in an office for sustained periods of time like they can be at work. Privacy concerns at home are very distinct from those at work, which is generally a more public space shared with a larger set of people within the work organization than the home.

### C. Awareness in the Mobile Context

Research has also started looking into context awareness on mobile devices. Lungstrand [13] identified the need for naturally sharing contextual awareness among mobile phone users to help evaluate their availability for receiving a call. Bentley and Metcalf [14] explored mobile user experiences that ranged from sharing lightweight presence and motion cues to engaging users in synchronous or asynchronous

communication. The added sensing capabilities included in mobile devices offers new kinds of awareness information that they can share.

Attempting to call someone on their mobile device adds much more unpredictability in their environment and their ability to take a call. While mobile devices often accompany their users most of the time, users only intermittently pay attention to their devices during a fraction of that time. Meanwhile, mobile smartphones tend to include many sensors (e.g., location, accelerometer, proximity to other people and devices) that can provide very useful awareness cues.

### D. Reconsidering Awareness in Today's Context

As a result of these evolving trends in technologies and use practices, it seems appropriate to reconsider our research and understanding on presence and availability. Even the use of the word "presence" to describe this affordance should be reconsidered. The rise of smartphone use means that I am almost always "present" to a mobile computing device, but it does not mean that I am always available for communication of any type. Much of the research to date has presumed a work context or not accounted for the pervasive availability of CMC capability at home or while mobile. These differences suggest reconsidering some of the research assumptions as we explore how availability affects usage and interaction across work, home, and mobile settings.

Furthermore, we may interact with a number of different tools on a number of different devices that enable real-time communication over distance. This proliferation of tools may mean that we need to learn how to interpret how they each represent awareness and availability information. Additionally, work practices have evolved such that we use some communication tools and devices for both work and personal use. We often receive urgent work chat communication and phatic personal messages on the same mobile smartphone, even though they represent dramatically different demands on our attention. Helping users manage communication requests is sensitive both to whether the request is work or personal and whether the user is currently in a home or work context.

Given the dramatically changed landscape of the use context of awareness and availability, we need to reconsider our research on availability and how to adapt it to this new landscape. Toward that end, we convened a discussion among people involved in products that have very different perspectives on availability to help identify new directions in availability research and design implications. We share our thoughts on these new directions with the research community to help stimulate new research along these directions.

## II. DIVERSE PERSPECTIVES

The authors on this essay represent the diverse perspectives discussed at our meeting representing a variety of CMC products. We include representatives from research, an enterprise unified messaging (Microsoft Lync: IM, audio, video, shared data) client, a consumer-focused unified messaging client (Skype), and a living room-based entertainment and communication console that uses the television for the display (Xbox). These diverse perspectives

helped us to see how these issues of availability and awareness are manifest differently in these different use contexts. Beyond the authors, the meeting also included a representative from our mobile smartphone division (Windows Phone). We reflect on the meeting to identify new ways of more comprehensively integrating across these perspectives in future research.

### III. KINDS OF AWARENESS INFORMATION

In the current landscape, there are several kinds of awareness information that we could share to support negotiating contact. We use “awareness” as the most general, umbrella term for all the different kinds of information that can help people negotiate starting communication. We outline three different types of information and the kinds of questions that awareness information can answer in negotiating real-time communication with a remote person.

- **Reachability**—Are they physically reachable for communication? Are they likely to respond soon, even if they are not immediately available?
- **Contextual Activity**—Is there some surrounding activity that would have an impact on their reachability or interruptibility for communication?
- **Availability**—Are they interruptible for a real-time communication now? If so, what is the preferred communication medium?

#### A. Reachability

Reachability refers to being capable of being reached for remote communication. More concretely, it describes the ability of accessing a communication device through which remote people can communicate. People are increasingly reachable for communication, especially with the pervasive use of smartphones or other mobile CMC devices that can both support communication and share digital awareness cues.

Nonetheless, there are still a number of situations where people are not reachable for remote communication. They may not have physical access to a communication device (left their mobile phone at home while running an errand), the device might be turned off or otherwise disabled (at night, being repaired), or the user may be in an area where its use is prohibited (certain areas in hospitals, certain times during airplane flights), or the device may be out of range of transmitting a communication signal.

Users may also choose to put themselves in an unreachable state. They can accomplish this by turning off the device, although this cuts them off from outgoing as well as incoming communication. Or, many CMC systems offer an “invisible” state which represents the user as unreachable, even though they may be reachable and monitoring others’ availability.

Reachability is one of the most basic types of awareness information, as there is no opportunity for communication if a user is not reachable. It is also a fairly unambiguous signal, without requiring much interpretation to understand whether the user can be reached for remote communication or not. However, reachability by itself does not help people negotiate how receptive they are to making contact at that time.

#### B. Contextual Activity

Prior research has identified various definitions for contextual activity, including Schilit and Theimer [15], who focused on location, nearby people and objects, and changes to those factors over time, Dey [16], who defined context as “any information that can be used to characterise the situation of an entity”, and Zimmerman et al. [17], who identified five context categories of individuality, time, location, activity, and relations. Building on this research, we focus on aspects of context that are salient to negotiating interactive CMC:

- **Intent**: purpose of the incipient communication
- **Frame of Attention**: current frame of reference for the participants’ attention
- **Locale**: circumstances around the participants’ locations
- **Time**: temporal factors and schedules for the participants
- **Activity**: both what participants are currently engaged in and activity happening around them
- **Relational Status**: social relationship between the participants
- **Vicinity**: people and objects nearby

It is important to consider these aspects of context for each participant in the communication. While there is some overlap and interaction among these aspects, we present this taxonomy to help think about the various attributes of context that are important to consider when socially negotiating making contact. We illustrate each of these aspects with more explanation and examples.

##### 1) Intent

The purpose or intent is the reason that one person is considering contacting another. An urgent work task request, a casual social chat, or notification of a family emergency illustrate the diverse range of intents for communication.

##### 2) Frame of Attention

The frame of attention refers to the general scope of each participant’s attention. Are they at work? At home? On vacation? Each of these frames of reference will have an impact on their availability to different kinds of contact.

##### 3) Locale

Locale refers to the environment around each participant’s location. Beyond just the longitude and latitude of the person’s location, locale includes some sense of meaning for the person. Are they at their house? At their work office? Are they mobile within the vicinity of their home? Are they traveling in a city away from home? While locale is closely related to frame of attention, it can add different information, such as when people are working from home.

##### 4) Time

Time refers to a range of different temporal factors. What time is it in the time zone of the participant’s current locale? Do they currently have an appointment scheduled in their calendar? Is an appointment about to begin or about to end?

What are the participant's typical temporal rhythms about commuting to work, eating meals, sleeping?

#### 5) *Activity*

Activity includes the current focus of engagement of the participant. Are they deeply engaged in some cognitive work, such as programming or writing? Watching TV or browsing the web for leisure? Attending a lecture or participating in a sacred service? Driving a car or sitting in a public transit vehicle? Talking on the phone with someone else?

Activity also includes what other people in the locale are doing. Is the activity of the people around the participant noisy or solemnly quiet? Are there other people doing the same activity together with the participant?

#### 6) *Relational Status*

Since communication involves at least two participants, there are often important social dynamics to consider around the relational status between the participants. Is a subordinate calling his boss? Child calling her parent? Wife calling her husband? The relative status among the participants affects their availability for different kinds of contacts.

#### 7) *Vicinity*

While the people and other objects nearby may be defined by other aspects of context, this may be a useful aspect to consider on its own. Is the participant alone or are there other people nearby? Is the participant's smartphone in his pocket or in a backpack nearby? Is there a computer or a TV nearby?

The opportunity in reconsidering awareness in the current landscape is that many aspects of contextual activity listed above can be sensed or inferred from computers or smartphones in broad use today. Online calendar appointments indicating current, upcoming, or soon to be ending scheduled activity, time zone information indicating if it is typically waking hours in the time zone they are located in. Audio sensors can discern being in a quiet/solemn place that should not be disturbed (such as a church or theater performance) or engagement in conversation or interaction with someone else (either remotely, via phone or video call, or face-to-face). Accelerometers can sense walking, driving, riding on public transit, etc. Even though the intent of a conversation can only be discerned in the minds of the participants, sometimes it can be inferred if, for example, the participants share an upcoming calendar appointment within the next fifteen minutes.

Being actively engaged with an input device on a computer device is an interesting kind of activity context that has come to be interpreted differently over time. Traditionally, inactivity in interacting with the computer (often represented as "idle") was used by IM clients on desktop computers to indicate if a user was not currently reachable through that computer. If the user was inactive on their computer, it was unlikely that they could immediately respond to an IM message. But the nature of the computer activity may also be important in interpreting whether the user is more or less receptive to communication at that time. For example, if they have been actively working in a programming environment for a sustained period of time, or are currently using presentation software, that may suggest that the user would like to avoid interruptions at the moment. But, if the user is active in an email or social networking application,

they may be especially receptive to communication at that time. Bailey et al. [18] show that the type of task the user is involved in affects their interruptibility. What application they are actively engaged with may be a useful activity cue to share to help people negotiate communication.

However, with the broader perspective of including home and mobile contexts, input device inactivity needs to be reconsidered. In the home, the computer is likely to be used more intermittently than the sustained work sessions that can be typical in the office. But, users can often be easily directed toward a computer in the home for communication, just as answering a home phone has become an established use practice in the home. Furthermore, game consoles and the TVs they are attached to are often turned off when not in use, unlike computers and mobile devices that are left on much of the time. While this prevents them from collecting, transmitting, or displaying any contextual activity that they may have access to, they are devices that can be quickly turned on and used for communication. In this sense, input idleness on devices in the home should not be interpreted as being unreachable or unavailable, in contrast to an inference typically made on work computers.

Input activity on mobile devices is even more intermittent than devices in the home. Oulisvirta et al. [19] documented how user interaction with mobile devices comes in short bursts that competes for the user's attention in navigating their environment and completing the task. This bursty nature of using mobile devices means that the user could be actively inputting information on the mobile device one second and could be shoved out of sight into a pocket the next. Despite long stretches of input inactivity on a mobile device, users are typically still reachable on their mobiles. Conversely, even very recent activity on a mobile device does not mean that a user would pay immediate attention to a signal sent to their mobile device. Again, input device activity on a mobile device needs to be interpreted very differently than that on a work computer.

Input device activity in home and mobile contexts illustrates a more general point. On work computers, there is more of a symmetry between being active on the computer and being reachable for communication through it. But for home and mobile devices, there is an asymmetry where users can be reachable despite being idle with respect to the device. Furthermore, being recently active on a home or mobile device does not as strongly correlate with being currently attending to that device as it does on a work computer.

Locale is another interesting and rich piece of context that can be readily digitally sensed. GPS information from mobile phones that move around with the participant or logging in to devices associated with different locales is readily available. Knowing whether the user is at work or at home invokes different sets of contextual logic for determining how receptive they are to different kinds of communication from different sets of people. Knowing where someone else is may suggest certain types of communications (e.g., requests for help with an errand), especially if they are nearby, which might suggest coordinating action for meeting up. Location can dramatically modify how other pieces of contextual activity are interpreted.

It may be important to consider the time context beyond just the current time. Upcoming appointments, end of work day, end of appointments, etc. may be predictive of whether users might be shortly receptive or unreceptive to communication. Begole et al. [20] demonstrated that contextual activity that has time ranges associated with it and historical rhythmic patterns in the user's activity may help predict transitions in the user's activity, which can be opportune times to try to contact them.

As the above examples indicate, sharing some of the contextual information can be self-explanatory in terms of their impact on the receptiveness to communication. Other kinds of information may need some inference (through either computational or human interpretation of the information). The richness of contextual information offers more cues to help people negotiate receptiveness to starting a conversation. But that richness can also add more complexity in having to process a wide range of differing bits of information. Furthermore, sharing this information can have significant privacy implications, depending on the scope and extent of who has access to it.

### C. Availability

Availability refers to knowing if and when someone is receptive to receiving communication, and what media channel would be most appropriate for that communication. Availability is perhaps what users most want to know in negotiating whether to start a communication attempt with a remote person. Yet, availability is a subjective judgement, requiring inferring or interpreting reachability and contextual activity information. While people are generally quite good at judging availability from the rich cues that are afforded when approaching face-to-face, the limited cues in remote CMC make judging availability a more challenging problem.

Traditionally, many IM systems convey some cues for contextual activity (e.g., input idleness, in a meeting, in another call) to enable remote users to make their own inference of availability. They also offer states that are explicitly set by the user to convey availability, such as a do not disturb mode. While such states enable a user to accurately broadcast an (un)availability state, it is prone to error in terms of users not setting it when needed or forgetting to reset it when they become available again.

Availability may also be sensitive to the mode of communication. Many public settings where an audio or video call would be disruptive (meetings, performances) could afford text-based messaging. Conversely, driving a car may be a good time to receive an audio conversation but would not afford responding to a text message. Yet, being a passenger in a car or on public transit (which may be hard to distinguish from driving) may suggest communicating by text rather than audio. Thus, availability can depend on the CMC medium, and awareness information could help users negotiate the appropriate way to contact a person in their current situation.

## IV. CURRENT CHALLENGES IN AWARENESS INFORMATION

Enabling remote users to make accurate inferences about availability information in the current landscape of devices,

tools, and contexts for wanting to establish communication is an area ripe for further research. This opportunity became clear to us in our meeting across a few diverse product contexts. We list some challenges that arose in our discussion in the following sections.

### A. Work vs. Personal Contexts

As mentioned earlier, most of the prior research in awareness and presence has been conducted in the work context. Yet communication availability in the workplace context is significantly different than in personal or mobile contexts. At work, people are traditionally considered to be available for work-related requests, within a sense of priority or urgency relative to other work tasks. But being at work traditionally provided a filter for what kinds of personal communication requests were appropriate during work hours. Brief or urgent calls were considered reasonable, but long and distracting personal phone calls often frowned upon. Conversely, work-related calls placed to the home usually needed to be justified with enough urgency or importance to be considered appropriate.

Yet, several current use practices make those distinctions difficult today. Many of our tools are used both for work and for personal purposes, so it is not as easy to segregate work and personal communication requests by the tool. For example, some enterprise communication systems (e.g., Microsoft Lync, IBM Sametime) also integrate with consumer IM systems, such as AOL Instant Messenger. Skype is used as a video chat system both for many businesses and for many families. So even if one could embody some design assumptions in how to differentially interpret contextual activity information for availability in work and personal contexts, the blurring of those tools for work and personal uses would confound the issue.

This blurring of use is perhaps most evident in the mobile smartphone. Whereas it used to be common to maintain distinct home and work phone numbers, the mobile smartphone typically goes with the user at work, at home, and wherever else. Thus, the mobile phone number becomes the universal and most convenient way to contact someone, whether for work or personal purposes. Similarly, people commonly used separate computing devices at work and at home, but since people only want to carry one mobile smartphone, it tends to be used for both work and personal uses. This blurring makes it hard to distinguish work and personal contexts of the activity cues that are sensed or shared by the mobile device. Furthermore, while the mobile device moves with the person between home and work contexts, it does not typically sense and reflect that context switching to the remote people who may use it to establish communication. It would be interesting to explore how a mobile phone could change the user's availability to home and work communication requests when the user transitioned from work to home contexts.

Furthermore, the boundary of personal and work is also being blurred. Increasing broadband connectivity into the home, decades of work from home and flexible work hours, and workplace response to busy lives has meant that more work activity happens outside the office and more personal activity is acceptable in the workplace. This blurring adds to

the challenge of interpreting contextual activity information when it can be unclear whether the person is operating in a work or personal context. Furthermore, that context can change on more fine-grained differences than whether they are in the office or not or whether it is during typical working hours.

### B. Mobile Devices

The advent of mobile smartphones adds several challenges to interpreting contextual activity for availability. Current mobile smartphone usage practice means that many users are always on and always connected. However, this does not mean that users are always available and interruptible. Contact through mobile devices adds challenges in interpreting the unpredictability of mobile contexts, yet also adds more sensing information that mobile devices make available.

Tamminen et al. [21] discuss how the different goals and activities of mobile users affect the design of context-aware mobile technologies. We have already discussed two challenges presented by mobile devices. Their intermittent and bursty use makes it more challenging to interpret the meaning of recent input device activity. Also, it is unclear if a user on a mobile device is operating in a work or personal context, which is an important cue for interpreting the awareness information.

Being mobile also means that the user's availability may change quickly, due to external changes in the user's environment (often beyond the user's control or ability to anticipate). Changes from waiting in line to being served or even a traffic light changing from red to green can instantly change a mobile user's availability in ways that are hard for the remote person to predict.

Additionally, some cues may be difficult to interpret without more fine-grained local knowledge. For example, while it is relatively easy to detect if a mobile device is moving in a transportation vehicle, it is rather harder to distinguish if the user is driving a car (less available for interruption, especially via text), or riding on public transit (more available for interruption, especially through text).

Having a mobile CMC device may help users fill time when they are out and about. The nature of mobile tasks often means that there are short spans of time that could be filled while waiting [21]. Designing mobile devices that help find others who are available to fill that time together or share those fleeting moments of availability to others could increase the opportunity for more interactive communication.

Meanwhile, mobile devices also bring a range of sensing capabilities that can provide useful awareness information. Location and accelerometer information can help remote users infer a lot about the context of a mobile user. Bentley & Metcalf [22] showed how providing information about whether a mobile user was in motion or not, without having to reveal exactly where they were, was enough to help close social contacts coordinate their activities. This research illustrates how selectively sharing information now readily available through mobile devices, in concert with the shared social context that close social contacts have, can effectively share awareness with close contacts without revealing private

information to those who do not have the social context to be able to interpret it.

### C. The Living Room

Several interesting challenges are also raised by communication systems that are used in the living room, such as networked TVs or game consoles. These living room systems are increasingly being used for communication, such as Skype-enabled TVs or multi-player online games. However, using these devices designed for the living room have special challenges for sharing awareness information.

As mentioned earlier, living room devices are typically not left on all the time, unlike desktop computers and mobile smartphones. Since TVs and game consoles are typically turned off when not in use, they cannot be used to notify people of remote communication requests, nor can they be used to collect contextual activity when turned off. Consequently, users currently tend to use other tools (IM or calls on other devices) to negotiate starting a session resulting in turning on the living room device and connecting over it.

Furthermore, multiple people often occupy a living room or engage with the devices in there. Unlike computers and mobile phones, which are typically dedicated to one user at a time, several people can be watching the TV together or otherwise be in the living room at the same time. Using these devices for remote communication may encounter conflicting availability cues from the different people in the room at the time.

Additionally, living room devices do not typically require any login process, unlike computers or the implicit personal ownership of mobile devices. Thus identifying users in the living room requires other techniques which may be less precise. This identification needs to be constantly updated as people naturally enter and leave the living room.

Contextual activities in the living room may also be more ambiguous to interpret. One may be watching TV to kill time, perhaps while waiting for opportunities of engaging with other people who might be available. Or, one may be watching TV together privately with a close friend, and not want to be disturbed. Or the TV may be on without anyone actually paying attention to it.

It might be expected that visitors to the living room (both in person and through CMC) are a more restricted set of people that have a relatively strong social tie to the inhabitants. Neustaedter et al.'s early research [11] identified three social groups active in the home: home inhabitants, intimate socials, and extended socials. Many current activities, such as watching TV together, Skypeing grandparents, and Google+ Hangouts with friends fit within those groups. However, more recent practice, especially around online gaming, has led to circumstances where strangers will be digitally invited into the living room to work together on a game. While gamers prefer playing together with people they know, since that increases the familiarity and accountability among the team, there are circumstances where strangers are included because the team needs a specific role at that time. The need for specific skills at specific times illustrates other dimensions that factor into availability in living room activities. The prospect of strangers

visiting the living room raises privacy concerns about controlling who can access the sensors deployed in the living room (e.g., camera, microphone) under what circumstances.

Another challenge of the living room is that users may have limited input affordances to interact with the computing device. Unlike the rich set of input devices available when sitting in front of a computer, or even the precise touch controls popular on mobile smartphones, interacting with the TV and game console is usually limited to the remote control. While technologies such as Microsoft Kinect and voice recognition are enabling gestural and other more natural interfaces, users currently experience less richness in their input interactions in the living room.

## V. OPPORTUNITIES FOR FUTURE RESEARCH

In this paper, we have reflected on how the current landscape of tools, devices, and use practices present an opportunity for reconsidering the research that has been done to date on awareness information. Our increasingly pervasive network connectivity presents a wider range of possibilities for establishing CMC. This technology-enabled increase in reachability brings with it the need to help users socially negotiate appropriate, convenient, and opportune times and means for making contact. We need to go beyond the work that has largely focused on managing availability in the workplace to consider the broader range of contexts where technology has enabled availability concerns to arise.

The blurring of work and personal boundaries, the rise of the use of mobile smartphones, and the advent of living room devices as communication systems all change the way that users interact with awareness information to infer availability of remote people for communication. Currently, users may have to deal with several different tools and devices that share awareness information. Each tool may do so in its own, idiosyncratic way, which can interfere with users' abilities to robustly and accurately interpret the awareness information shared across tools and devices. It is also important for the user to have a sense of who can see what about their activities, in case there are some privacy issues that need to be safeguarded. While one might have hoped that the increasing popularity of using awareness information in communication tools would have increased the accuracy of availability inferences, the current uncoordinated and understudied nature of it ironically interferes with its meaningfulness and the ability to consistently maintain privacy. These concerns became clear as we discussed this issue across communication products aimed at diverse use contexts.

One opportunity enabled by the increased use of devices that share awareness information is that it may make it easier to find people to interact with when you are not explicitly seeking out making contact with them. While much of awareness research to date has focused on if and how to contact someone when you want to reach them, a new research opportunity might be making you aware of people available for interaction just when you have some time available. Just as social networking tools have increased our ability to stay socially connected through largely asynchronous interaction, new awareness tools may extend our ability to synchronously and

gracefully interact with people under the right time and availability conditions.

One concern with adding more kinds of awareness information and more contexts in which it is collected is that it risks adding more complexity and uncertainty in interpreting the awareness information. Clearly we do not want the user to confront too much information that they have to analyze to come to an availability conclusion, even though people are probably better at making those inferences than computers. A design challenge is figuring out how to distill that information into a representation that gives the user a quick and clear signal of availability (perhaps with an opportunity to drill down for more details). A particular concern is whether expanding the scope of awareness information introduces more error or uncertainty in the availability signal. Interpreting awareness information within the relatively homogeneous context of a work culture is probably less prone to error than adding the diversity of home and mobile contexts. If users perceive that the signal is unreliable, they will begin to ignore it, rendering the signal useless. One design alternative is to show only information that is less ambiguous (for example, focusing only on reachability). While this approach may not be able to help users make nuanced decisions about availability, there is less uncertainty about its accuracy.

Even beyond the scope of this article, which focuses on usage practice in North America, considering awareness in different cultures may have very different use practices and interpretations. For example, while mobile devices are implicitly assumed to be individually owned in developed countries, research has shown how mobile devices are more shared in developing countries [23]. Exploring cultural differences in the usage and interpretation of availability signals is a line of research that would be important for developing products that would translate into global contexts.

Thus, we think this is a good time to reconsider research on awareness information across the tools, devices, and contexts in which it is currently used. It would be interesting to conduct new studies of what kinds of awareness information people would like to make use of across the different contexts of home, work, and mobile. It would also be interesting to see how our current technologies could provision that awareness information, while still preserving user control of privacy and plausible deniability and without adding too much complexity.

We hope that by articulating these challenges and opportunities in this essay, we can help encourage more research in this area to help improve the usefulness of the availability information offered in our tools. This research may leverage the increased sensing capabilities of smartphones (location, sound, accelerometer) and advances in machine learning or even crowd-sourcing to help develop robust models for interpreting awareness information into availability for communication.

One design implication to explore from this work is to develop a framework or communication protocol for sharing, exchanging, and consuming awareness data among the diverse range of applications and devices that are involved. We imagine an availability service that collects awareness and availability information from all available sources (perhaps

both at the raw data level and at the level of availability inferences that certain applications make) and processes them to help applications make contextually appropriate availability predictions. We expect that designing such a service will help identify ways in which awareness information can be shared to enable applications and their users make full use of that information to negotiate making contact.

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