Communicating in a Ubicomp World: Interaction Rules for guiding Design of Mobile Interfaces

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Abstract. As computing resources become accessible anytime anywhere, rules of interaction and engagement between humans are changing. For example, response-time expectations have dramatically decreased in recent years because of the assumption that recipients are constantly checking e-mail and text messages on their mobile devices. Likewise, expectations of context-awareness have become an important part of interactions. For example, the tag-line "Sent from my iPhone" is a means of conveying the context (mobile) of the message sender, which also serves to explain—or offer an excuse for—the brevity of the response. In this manner, there are several design strategies that are needed for managing expectations, as new rules of interaction emerge due to the ubiquity of our access to computing resources. This paper presents a list of 12 such interaction rules based on theory and research in interpersonal communication and psychology. These rules provide design ideas for mobile ubicomp interfaces.

Keywords: Mobile HCI, Ubiquitous Computing, Interpersonal Communication, User Psychology

1 Introduction

The arrival of "ubiquitous computing" has meant that we are constantly surrounded by a plethora of computing devices that allow us to communicate with others and access information anytime anywhere. While this offers a whole range of fascinating possibilities, we also face significant challenges of reorienting our communications and designing interfaces that better support people's daily activities in a ubiquitous computing (ubicomp) environment. An emerging research need in this area is to understand how ubiquitous computing influences the manner in which we interact with

others. For example, we become more and more accessible to others through ubiquitous devices, such as smart phones and tablet computers. However the always-on environment also burdens our lives since the lines between our social and private lives become blurred [7]. In this paper, we discuss such challenges that ubicomp environments bring to the communication process. We begin with an example that illustrates how ubiquitous computing has changed our expectation of the way we interact with others. We then present some interaction rules that have emerged since the arrival of ubiquitous computing. Everyday examples are provided to illustrate how each interaction rule influences our communication process and the issues that it raises. Also, the paper discusses related studies in the literature that can provide insights into how we should address the issues. Finally, it proposes design recommendations for mobile interfaces and research questions that can be addressed in future studies.

2 Changes In Interaction Rules In Ubiquitous Computing Environments

How exactly did ubiquitous computing change the way we interact with others? A good example is our changing expectation with regard to e-mail response time. When laypersons started using e-mail in the 1990's, the infrastructure was not advanced enough to offer users easy access to their e-mail services, given limited computer availability, unstable Internet, and the high cost of using Internet. Due to this limited access, users did not expect others to check e-mails constantly. It was common to wait several days before getting a reply, so we seldom complained about e-mail responses that took a few days. However, in the first decade of the 21st century, accessing the Internet became much more convenient, and computers became available to many more people, in many forms, and in many places. With improved infrastructure, people now expect others to have easier access, thus raising their expectations for receiving prompt replies. Many users now expect a response the same day. Some users complain about others' lack of e-mail responsiveness, and other users complain about feeling pressured to meet e-mail senders' expectations (e.g., professors complain that students tend to send them a follow-up e-mail if they do not respond to their initial e-mail within a day). With the recent proliferation of ubiquitous computing, particularly smart phones, expectations for getting replies within a short period are even higher. Now, users are able to check e-mails almost anytime anywhere, and they assume that others have constant access to e-mail services as well.

This example demonstrates that advances in communication technologies have influenced our perceptions and expectations for interacting with others. In order to cope with such situations, users make adjustments and announcements in order to prevent conflict and promote communication. In the aforementioned case of e-mail responsiveness, users manage others' increased expectations by setting away-messages when they are not able to reply to e-mails for a couple of days. Some instructors tell students about their e-mail usage habit in advance so that students know what to expect (e.g., "I do not check e-mail after 5pm. E-mails sent after 5pm will be replied next morning").

Instead of such offline "announcements," the applications and devices themselves should be able to serve e-mail senders as well as recipients. This paper argues that mobile interfaces and other ubicomp devices can and should be designed to support users to overcome issues brought about by such changing rules of interaction. In the next sections, we present an initial set of 12 interaction rules and provide design recommendations for interface features that may help users manage their daily lives in ubiquitous computing environments. These rules are grouped under six categories based on conceptual similarity and commonalty in design solutions. We started out with a larger set of rules and identified interpersonal communication principles that are common across them. Those that shared a similar principle were grouped so that we can arrive at common design solutions for each group of rules as a whole.

2.1 Communicating Access to Manage Uncertainty and Others' Expectations

Communication in ubiquitous computing environments can be characterized as "always-on." Users can be reached by others at all times through different kinds of communication devices. At first sight, the ubicomp environment seems to bring a lot of convenience and flexibility for us to communicate with others. However, the "always-on" environment can also increase uncertainty in the communication process and heighten the pressure to meet others' expectations. Below, we describe two interaction rules that pertain to these issues.

Rule # 1: Users make inferences about other users' access to ubiquitous computing. Given the anytime-anywhere assumption, we expect prompt responses to our messages. However, we do not always receive responses promptly. There are some occasions when users are unable to access ubicomp or don't want to be reached by others (e.g., during a meeting) or do not use a particular Ubicomp tool. However, since we do not always tell others explicitly about our access to ubicomp resources and of our availability, those who initiate communications might undergo anxiety and uncertainty (e.g., worry about why the person did not reply to the message; thinking that she doesn't pick up the phone because she is mad at me).

In the same vein, people tend to be mindful of other users' ubicomp behaviors. They observe others' access and use of ubicomp tools in order to infer their individual behavioral norms and thereby manage their own anxiety and uncertainty. A dominant observation pertains to the temporal aspect, i.e., "when" a particular other will access ubicomp. Other observations span a wide range, from tool usage habits to contextual information (e.g., location of recipient, urgency of topic, one's schedule) [36]. For example, if you usually take one day to respond to e-mails, others will infer that you have daily, rather than round-the-clock, access to e-mail and will accordingly adjust their response-time expectations. Similarly, we often expect others to check e-mails less frequently during weekends. That is why we will not get upset if we do not receive a reply until Monday [36].

Another common inference pertains to others' media preferences. Ubiquitous computing environments offer users a vastly increased range of communication media.

Previously, users had only a handful of ways for reaching others, such as talking face-to-face, calling through landline phones, and writing letters. The advent of the Internet expanded this choice set to include instant messaging (IM), e-mails, and social networking sites. However, these new types of media are not always available, given users' limited accessibility to computers. The proliferation of ubiquitous computing, particularly the rise of mobile devices, has set us free from such restrictions. We are now able to use a wide variety of communication media at any time and in any place of our choosing. We also have a rich choice set for deciding which medium to use for which occasion.

Selecting an appropriate medium is important since each medium has its own characteristics that make its use appropriate for some situations, but not others [22,39]. For example, if you have a casual acquaintance who happens to be on your list of Facebook friends, you would not think of calling them on a telephone to wish them on their birthday. This gesture is usually reserved for those individuals that we know at a more personal level. Instead, the norm would be to pen a greeting on the person's Facebook wall, so that the birthday wish is delivered in a less intrusive fashion. Of course, such decisions are predicated on inferences made about the recipient's use of these different media channels—something that the latter can control, in order to shape sender's expectations, as we specify in our next rule.

Rule # 2: Users develop their own methods or habits for gaining agency of ubicomp use, as a way of managing their availability to others. Meeting others' expectations is critically important for successful interpersonal communication. For example, expectancy violation theory (EVT) suggests that when an individual's expectation is violated, they actively evaluate the violation. If the violation results in a better-than-expected outcome (e.g., receiving e-mails quicker than expected), they evaluate it positively. However, in the event of a worse-than-expected outcome (e.g., receiving e-mails slower than expected), they evaluate it negatively [29].

In a ubicomp environment, managing others' expectations is a challenge. For example, we sometimes fail to reply to others as promptly as they may have expected. In such cases, the senders might feel frustrated at our lack of responsiveness and therefore form a negative impression. In fact, studies have already noted that responsiveness can influence the impression we leave on others [e.g., 36]. Therefore, it becomes important for users to manage others' expectations of their availability.

Many users do so by engaging in behaviors that block others' access to them (e.g., turn the sound off or switch off mobile phones). Users sometimes also choose who can reach them and provide selective access [1,10]. Previously, they were able to create boundaries between their different circles because the communication was mostly bound to place. For example, people interacted with their co-workers in their offices, while having time with their family or friends once they left the offices. However, ubiquitous computing blurs the boundaries between their circles by making interaction possible regardless of place. Therefore, users are now having to manage their availability based on their circles. An example of such availability management is to have two mobile phones--one for personal communications and one for work-related purposes. In this way, they can switch off the work-related mobile phone after

hours, and only allow their friends and family to reach them through their private mobile phones.

Lying behavior also plays an important role in users' management of their availability. Studies have found that lies are sometimes necessary for facilitating interactions [2,37]. Hancock and colleagues introduced the concept of "butler lies" to describe the type of deception that helps users manage their interaction with others [16]. For example, a user might lie to others that she is busy in order to avoid starting a conversation on IM. Similarly, users sometimes make up reasons to explain why they were not available for a call (e.g., "sorry I couldn't pick up your call, I left my phone at home"). Their field study with 50 IM users revealed that one out of every ten messages has some sort of deception, and about one fifth of the deceptions are butler lies.

Design Recommendations. These rules suggest that users strive to make precise assumptions about others' ubicomp availability, but at the same time try to control their own availability to others. Ubicomp devices should be designed to help users to cope with these contrasting needs, as suggested below.

1. Allow users to communicate availability and media preference in a more fine-grained manner. Current technologies already offer some features that allow users to communicate their availability (e.g., status in IM). However, we propose that such indicators of availability should contain more detailed information, such as users' turnaround time. For instance, before we send an e-mail message to someone, our e-mail interface could inform us how quickly that person will be able to respond to e-mails on average during that day or week. In this way, message senders can make more accurate assumptions about the receivers' access to ubicomp, while receivers meet senders' expectations by setting their own average time by themselves (see left-hand side of Figure 1).

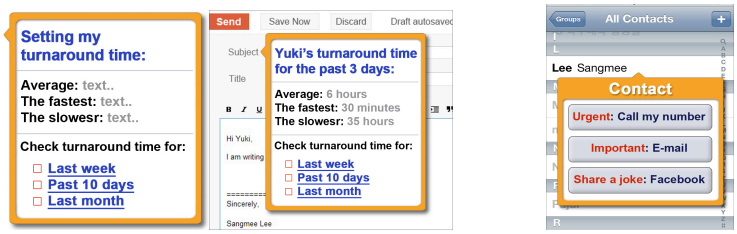

Fig. 1. Prototype of an interface that informs users about the turnaround time of the information recipient (left) and others' media preferences for contacting them (right)

Similarly, the design of ubicomp should help users communicate their media preferences to others. Specifically, a triage mechanism is needed for ubicomp interfaces, functioning as an intermediary channel (or initial filter) for aiding users' selection of particular media. For example, a system can allow users to show their media usage preferences to others. Each user customizes a list of preferences in advance. One user might specify that if a message is urgent, then the sender should call their mobile

number, but if it is not urgent but important, then they should e-mail the recipient. If they simply want to share a joke, then they should connect via Facebook. For another user, the media preferences for the same set of communications could be SMS, IM and E-mail respectively. If each user generates such a list of preferred media for common categories of communication, and if this can be seen by others at the time they decide to initiate communications with the user (such as when they click the user's name on their mobile phone contact list or put the user's e-mail address on their e-mail client), then message senders can choose the appropriate media for their interactions, thereby minimizing mismatches (see right-hand side of Figure 1).

2. Make users aware of their own ubicomp access and usage patterns. The interface could also help the user manage others' expectations of him/her by monitoring his/her response behavior and providing adequate advice and support. For example, the system can inform the user how quickly she typically replies to e-mails based on the urgency of the communicated event. If the user is replying to a non-urgent e-mail rather quickly, the system could notify the user and automatically retain the e-mails in the Outbox for a while before sending it out. In this way, the user can maintain consistency in his/her response-time, which would prevent others from holding false or unrealistic expectations that are likely to be violated.

3. Allow flexible customization. In addition, the design of communication interfaces should allow users to customize their availability based on their relationship with others [28]. Just as social networking sites these days allow users to share information to certain groups of friends, users' availability could be differentially indicated to different groups of contacts. For instance, mobile phone interfaces allow users to group individuals in their contact lists based on their circles. Users, then, can set which group of people can reach them based on time or occasion (see Figure 2). If a user receives a call from a person to whom the user prohibited access temporarily, the system could play a voice message or send a text message to explain their lack of availability.

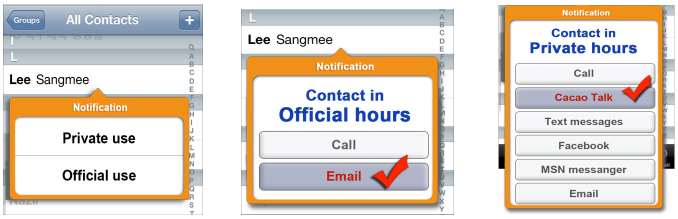

Fig. 2. Prototype of an interface that helps users to choose appropriate media for contact depending on individual or group of receivers

2.2 Providing Context-Awareness

Traditionally, contextual cues are relatively scarce in computer-mediated communica-

tion compared to face-to-face (FtF) communication [31]. However, with the development of ubicomp and communication technologies (i.e., video chatting, GPS function in mobile phone), the amount and type of contextual cues have changed, giving rise to new challenges and novel interaction rules aimed at coping with them.

Rule # 3: Users are oblivious to receivers' contextual constraints while communicating with them. Contextual information, such as place, time, and presence of others, provides cues for us to make judgments about what and how to communicate at any given moment [8]. Studies in computer supported cooperative work (CSCW) often highlight the role of contextual cues to establish common ground and facilitate communication among users [5,26]. Although CMC tools are generally low in contextual cues, older communication technologies, such as landline phones, still provide a certain amount of contextual information to users. For example, when we call landline phones to reach someone, we know where the person is (e.g., office or home). The call is sometimes picked up by somebody else, which is another piece of information telling us who is there in addition to the person we want to reach. On the other hand, ubicomp connects a person to another directly. In such a scenario, the amount of contextual cues that is available to users is dramatically reduced. As a result, callers will be less aware of the context of their communication partners. Calling somebody who is driving is a good example. Callers usually do not know whether the person is driving before initiating the call [3]. They might not even pick up on this cue if the receiver does not explicitly mention it (callers usually assume that if receivers pick up the phone, they are situated in a context that is appropriate for them to talk), and therefore may not factor in the divided attention that usually accompanies talking while driving, not to mention other contextual factors such as noise and passenger distractions. As a result, callers may not cadence their communication adequately to suit this situation, i.e., they may talk too fast or too softly, resulting in miscommunication or poor communication, or may not realize that they are on speakerphone and therefore reveal information that ought not to be heard by others in the car.

Rule # 4: Users expect context-awareness of interaction. Since it is becoming common knowledge that ubicomp deprives communication of contextual cues, some CMC interfaces have started enabling users to attach contextual information to their messages. For example, when a user sends e-mails from his/her mobile phones, an automatic signature at the bottom proclaims "sent from my iPhone (or Blackberry)". This kind of cue can communicate the fact that the sender was constrained by their device when sending out this message. If the message receiver knows that the e-mail is sent from a mobile device, they may show more tolerance towards short, cryptic sentences and greater willingness to overlook mis-spelling, grammatical errors and unorganized sentences. Further, such contextual information may serve to add value to the communication, and in some cases lead to greater enjoyment of content. For instance, when users see a picture uploaded in Facebook with the tag-line "uploaded from iPhone," they will infer that the information was shared soon after the event happened. Such recency cues could enhance the perceived freshness or timeliness of

the communicated event [38] and thereby determine how the content of the communication is perceived.

Studies have attempted to identify contextual information that is important for influencing users' interaction with others through ubicomp [11,30]. De Guzman and colleagues studied types of contextual information that people use for deciding whether to initiate a call through mobile phones [11]. Their results showed that activity information (e.g., what activities receivers are doing at that time) was used most often to gauge one's availability to accept calls. However, they also found some discrepancies between types of contextual cues used by callers to make calling decisions and types of cues that receivers wished callers to consider before initiating calls. Specifically, receivers want callers to consider their task status (i.e., whether receivers are occupied by other tasks), physical availability (i.e., any physical barriers that prevent receivers from accepting the calls), and social availability (i.e., whether answering a call is socially awkward) more often than what callers normally would do themselves (34% vs. 22%; 21% vs. 18%; 15% vs. 9%, respectively).

It should be noted that people desire control over the degree to which information about their context is made available to others. Just because one is physically accessible does not mean that she is truly available for communication. In such cases, users may not truthfully let others know their contextual information, but would rather make up some white lies to manage their availability (e.g., avoid attaching information such as "sent from my iPhone" on their messages because they do not want others to know their accessibility via mobile phone at that time). Such lying behavior becomes necessary for facilitating interactions [2,37].

The control over the amount and types of contextual information shared is also important for protecting user privacy [9]. Increasingly, location sharing services (e.g., Foursquare) are offering users new ways of socializing with others, but they also bring with them important privacy concerns. According to a recent study, over 50% of individuals are concerned with privacy when they use location-based services [23]. Therefore, privacy needs are paramount when exchanging contextual information.

Design Recommendations. The examples and studies mentioned above illustrate the importance of context awareness for both senders and receivers of communication. Therefore, ubicomp interfaces should be geared towards allowing users control over how they communicate their context.

1. Give users control over when to share contextual information. Users should be able to have the control to release contextual information to others rather than letting devices automatically detect and transmit their situation to others. For example, a device could allow users to customize many types of "situation" settings (e.g., driving, having an important meeting, unable to access Internet/mobile phone) in advance. When necessary, users should be able to turn these settings on and off (see Figure 3).

Once a setting is turned on (see Figure 4), the device would automatically tell others why a user is not available, and the device would stop attaching unwanted contextual information (e.g., if a user turns on the situation setting of "unable to access mo-

bile phones", then the tag-line "sent from my iPhone" will not be shown on the message even when the user sends the message from his/her iPhone).

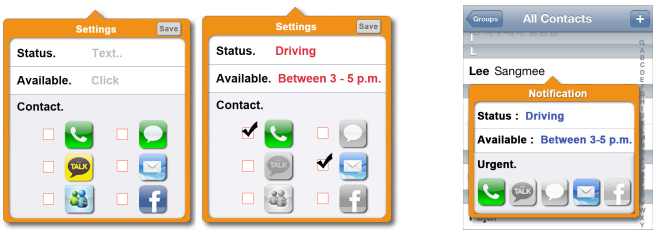

Fig. 3. Prototype of an interface that allows users to specify their availability and media preferences (left) and the manner in which it will be displayed to others (right)

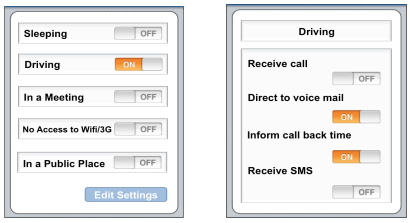

Fig. 4. Prototype of an interface that allows users to customize their situation and communicate their context to others

2. Give users control over how to communicate contextual information. Another important consideration is the manner in which contextual information is communicated. For example, when we share location information, most of the current applications show where a user is by way of detailed geographical information, such as street address or latitude. Sometimes, such information is indeed what users want to share, but not always. Designers ought to be more attentive to how people tailor the information when they decide to communicate it. For example, Lin and colleagues [19] pointed out that users use a rich variety of terms to refer to their location. If one is at Starbucks, she can refer to it as "a coffee shop" or "Starbucks near the public library" (labeled as "semantic information" in their study) instead of providing detailed geographic information. In addition, the decision regarding which term to use is based on various factors, such as the nature of the social relationship between information sharers and receivers, comfort level of sharing (e.g., privacy concern), recipient's familiarity with the place, and place entropy (i.e., how public the place is). Specifically, individuals use semantic information to refer to places when the information is shared with less intimate social groups, when users have higher comfort level of sharing the location, when they are not familiar or extremely familiar with the place (i.e. geographical information use is high when the familiarity level is moderate), and when the place entropy is low (i.e., the place is less public) [19].

2.3 Processing Information in Ubicomp Environments

Ubicomp gives us constant access to abundant amounts of online information from multiple sources. In addition, it lowers the hurdle of information sharing, which also increases the net amount of online information that we can access and use. Nowadays, it is common to see some users reading online news through their computers while checking on their friends' Facebook status updates through mobile devices. As a result, the amount of information that users encounter and deal with in their daily lives has increased significantly. Two interaction rules address this transformed information environment.

Rule # 5: Users will draw meaning from affordances. What happens when people need to deal with excessive amounts of information? Studies in psychology and communication have noted that individuals tend to process information heuristically (i.e., effortless and based on situational cues) rather than systematically (i.e. effortful and analytical) in online environments as a way to deal with the abundance of information [20]. The affordances or interface cues become important in heuristic processing because it helps users to make sense of the information instantly [33]. For example, when users visit a website for the first time, they often check the design of the site to form an initial impression. If the website design looks professional and easy to navigate, they are more likely to think that this website is credible, and thus decide to explore the content further. This positive impression of the site can extend to individuals and organizations that offer the affordances. For instance, great navigability in an organization's website imply greater attention to users' accessibility and convenience, and therefore project an image of caring on the part of the organization [33].

Rule # 6: Users will read meaning into others' use/nonuse of affordances (and ubicomp itself). The fact that one chooses to use an affordance (or not) can, by itself, convey meanings as well. Suppose a restaurant puts their customer ratings on their website. People who see the site will evaluate the restaurant not only through the content of the rating (i.e., four stars, the number of thumbs up), but also by the fact that the rating is even offered in the first place (implying that they care more about customers and place higher value on accountability). Other examples include affordances offered by Facebook, such as whether users use status update, have filled in their profile information, and uploaded pictures on the site. Let's take relationship status update as an example. If you are single but if you do not use this affordance (i.e., not declare that you are single on Facebook), it might signify that you are not proud of being single or not interested in getting into a relationship. On the other hand, if you are in a relationship with someone but do not use this affordance (i.e., not declare that you are in a relationship with so and so on Facebook), your partner might think that you do not care enough about the relationship with him/her or feel uncomfortable telling your friends about the relationship. In this way, the sheer use/non-use of interface affordances can lead to inference of meaning.

Design Recommendation: *Help users become aware of and unpack the meaning of affordances.* The issue with affordances in ubiquitous computing environments is that users are not fully aware of the way others "read" those affordances. Without having a mutual understanding of the meaning of a given affordance, users may face conflicts during the interaction (as in the example of the Facebook relationship-status symbol). In fact, studies have noted that the social nature of information sharing places impression management at the forefront [18,24,38]. Therefore, ubicomp devices should alert users about the consequence of their affordance use (see Figure 5) and help them manage their impressions through appropriate use of affordances. For example, whenever a user starts to use a new site that is open to the public, the interface could make suggestions about the types of affordances that the user can use to project their ideal image to others. The system can also inform users about how other people may interpret the affordance, so that the user can better manage their impressions.

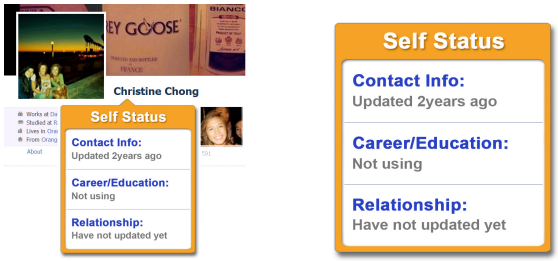

Fig. 5. Prototype of an interface that informs users about others' use/nonuse of affordances

2.4 Providing Awareness of Behaviors in Public

Use of computing devices in public places has increased dramatically in recent years. Nowadays, it is quite common to see people using mobile phones, laptop computers, and portable media players on the streets, at coffee shops, and in public transportation, leading to changes in interaction rules in public places.

Rule # 7: Users' perceptions of what is "appropriate" ubicomp usage behavior in public spaces are changing. Rule # 8: Users' tolerance for others' use of ubicomp during face-to-face communications is increasing. One noticeable change after the increased use of media in public places is our view of others' behaviors and our perceptions of what are appropriate things to do in public places. For example, previously, using mobile phones in public was considered impolite and improper. We used to get annoyed by others' phone conversations. But now, we seldom pay attention to people who are talking on their mobile phones in public places, and treat them as if they are talking with their friends walking next to them (Rule # 7). Likewise, we used to hear that people were irritated by the noise from other people's use of laptop computers in public places (e.g., tapping keyboards). But, we somehow got accustomed to

these sounds, and using laptop computers in public places has now become very common and accepted in most places (Rule # 8).

Rule # 9: Our very conception of "public space" is also changing. In addition to the changing notions of "appropriateness" in our public behaviors, our notion of what is "public" itself seems to have undergone a change. Previously, public space was seen more as a place for interacting with others. People might chat with their friends or strangers co-located at that place or watch other people passing by. These types of interactions made individuals aware of others' co-presence in a public place. However, ubicomp access reduces the interaction with co-present others since users often flip open their individual mobile devices in public places. Such behaviors might make them feel that they are in their private space although they are physically located in a public place. As a result, users may feel that it is safe and appropriate to reveal their private information in public, making them vulnerable to privacy intrusions. Studies have noted issues resulting from people's use of personal devices in public places. First of all, individuals seem to decrease their serendipitous social exchanges with others when they use personal devices. Hampton et al. [15] found that wireless Internet users and mobile phone users are less attentive to people nearby and less approachable by others. Such decreases in social exchanges can hurt the formation of social capital [4] and hinder public discourse that is so essential to a democratic society [12]. Secondly, although people have increased their tolerance for others' personal media use in public, some behaviors, such as talking too loudly, can still cause conflicts. A report from the University of Michigan noted that more than 80% of people have been irritated by others' annoying manner of mobile phone use [35]. In addition, use of personal devices can make co-located companions uncomfortable since they may feel left out of the conversation [15]. Since such behaviors can strain relationships and impact impressions, we need solutions to help users to control their seemingly irresponsible and anti-social behaviors in public.

Design Recommendation: *Remind users about the "publicness" of their physical location.* The consciousness of public-private boundaries is fleeting in the ubiquitous computing environment. Therefore, interfaces should provide constant reminders of the "publicness" of their surroundings to users, so that they are constantly aware of what they should or should not say and do at any given moment. In addition, one's access of ubiquitous computing itself has plenty of meanings. Others would judge a user based on when, how, and with whom a user accesses devices. Thus, interfaces should alert users about their frequency of use, location of use, and the type of people around them while they are using the device (see left-hand side of Figure 6).

In this way, users can gauge the appropriateness of their device use and make necessary adjustments to their behavior. For example, using a mobile phone during talking with your school friends at a coffee shop might not be an issue. However, when it comes to a first date at a fancy restaurant, such behavior could imply rudeness or your unwillingness to engage with the date. To prevent this from happening, ubicomp devices could remind users where they are and who else is around. Such contextual

information should be both automatically detected and inputted by users in advance. For instance, the location could be detected by the device, based on which it could access the user's calendar and address book to ascertain the identity of the meeting partner. Another way of managing the boundary is to specify how often your system will push your received messages, missed calls, and other media updates to you (see right-hand side of Figure 6). This would effectively work in other public places as well, such as when traveling on a train at night, or when you have an important meeting but are also expecting a time-critical email message.

Fig. 6. Prototype of an interface that alerts users about the location and the number of people around them (left) and prototype of an interface that can be customized for pushing updates at regular intervals (right)

2.5 Supporting Users' On-Site Planning

The availability of anywhere-anytime information access has changed how we plan our daily schedules and plan for our future events. We propose two interaction rules relating to this topic.

Rule # 10: Users are less likely to stick to schedule. Previously, if we scheduled a meeting with someone, we often decided on a detailed plan (e.g., exactly what time to meet and where to meet). Since last-minute arrangements were difficult to make, individuals tried to stick to the plan and avoid unnecessary changes in their appointments. However, ubiquitous devices enable us to rearrange our schedules and appointments easily, which eventually influences our planning behaviors. Nowadays, it is common for us not to discuss detailed schedules and plans before an event. For example, it has become common for us not to decide on the exact place to meet in advance. Instead, we typically call each other at the meeting time to figure out where our partners are and decide where to meet.

Rule # 11: Users are more likely to access information at the time they need (just in time), and therefore are less likely to prepare in advance. We now depend less on pre-planning since we can schedule things at the point of service through ubiquitous devices. For example, we would previously make a detailed plan when we went on a trip, such as where to eat, which public transportation to take, and how to get to a

particular place. Nowadays, we can easily find such information through ubiquitous devices at the time we need it. Such convenience means users are less likely to prepare things in advance (e.g., print out boarding passes before heading to the airport).

Design Recommendation: *Remind users about situational constraints that restrict their Ubicomp access.* Since people are getting so used to accessing information whenever they want, they tend to forget that accessing ubiquitous computing might be difficult in some places (e.g., weak Internet connectivity, low on battery). In addition, some information might not be accessible or hard to find on the Internet, so it is better for users to make necessary arrangements in advance on some occasions. Ubiquitous computing should predict such situational constrains and remind users about them. For example, when a user is entering an area with no wireless connection, the device could alert them so that the user can access whatever information they need before losing the connection. Similarly, once users tell a device what they need to do at their destination, the device could tell users what types of information they can and cannot access at the site so that they can accordingly plan their use of time before and during the event.

Also, in the context of a group rendezvous, it might be efficient and effortless to invite the attendees to a chat room and directly share their respective location information with all other attendees. Users will be able to instantly check where their friends are and how long their friends might take to get to the location. Moreover, they can call or send a message, supporting their on-site planning (see Figure 7).

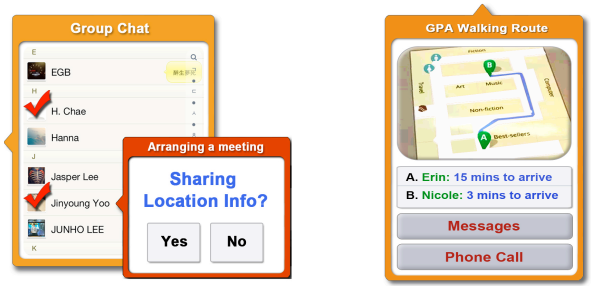

Fig. 7. Prototype of an interface that provides location and contact information of others arriving to a meeting

2.6 Assisting Digitalization

Rule # 12: Users depend more on digital, rather than tangible, artifacts (what is digital is usable). Data digitalization is important in ubiquitous computing environments. In the last two decades, a variety of things have become digitally available, such as books, music, and videos. As a result, we have increased our dependency on digital content because it offers us many advantages. For example, digital content is easy to carry (e.g., students do not need to carry heavy books if they have a digital book reader with digitalized book content). Also, digital data provide easy handling of

information search (e.g., using search function to find a file from folders or words in a document), information sharing (e.g., upload data online), and content editing. Given these conveniences, people, especially young users, have developed a preference for digital data over physical artifacts.

Studies have noted an increasing tendency among young users to prefer digital possessions over tangible ones. Odom et al. [25] found that teenagers prefer digital possessions because of accessibility (i.e., users can ubiquitously access data), accrual of metadata (i.e., users write comments or tag their friends on photos uploaded on Facebook as a way of accumulating social metadata), and easy presentation of self to multiple audiences (e.g., users customize their blog interfaces to convey their tastes and personalities to blog readers).

Design Recommendations.

1. Support digitalization and retrieval of digitalized data. Given users' increasing preference for digital data, ubiquitous computing environments should make it easier to digitize things around users. Also, these digitized data need to be easily accessed across users' locations and devices. For example, users' personal devices should automatically share data instead of asking the user to download and sync the data every time manually (e.g., iCloud). The system should also make it easy for users to upload these digitized data onto social network sites, so that users can accrue metadata with their friends and use the digitalized data as a tool to present themselves to others.

2. Be aware of the negative outcomes of intangibility. On the other hand, as pointed out by [25], we also need to pay attention to negative outcomes of intangibility. It is human nature to develop an attachment to their possessions. Such attachment would make them cherish the possessions more (e.g., people refuse to switch their old mobile phone to a new one because they feel attached to the old one) and would also provide psychological comfort to users (i.e., children cannot sleep without their favorite blanket; grandmother remembers her children by seeing the clothes they wore when they were kids.) [21,27]. However, we currently have little knowledge about whether users are still able to establish such attachment with virtual possessions. Researchers and designers need to attend to this potential loss of attachment to virtual possessions and provide design solutions to overcome it.

One solution may be to apply the metaphor of offline possessions and the routines surrounding them. Packing things in our own backpack is a good example that can be applied in the digitalized world. By applying this pattern of behavior, users may have more attachment toward organizing and sharing data among systems. Suppose you are preparing materials for a class, you may need textbooks and apparatus. When you click the category of Apparatus on the interface, you will get a list of apps (see Figure 8). For textbooks, you can manage files based on lectures. If your applications do not support the material in digital form, type the list using *Notice* function so that you can make a list of needed tangible materials that could be prepared in advance. In this way, metaphors of analog possessions that are known to elicit user attachment can be used for designing tools for organizing and managing one's virtual possessions.

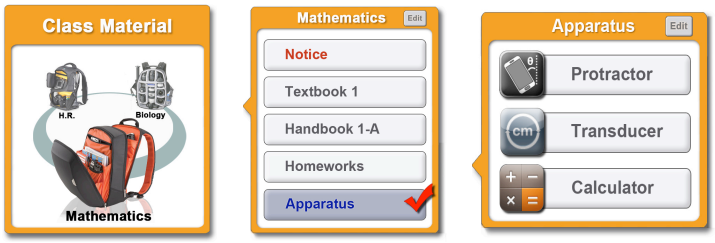

Fig. 8. Prototype of an interface that reminds users of traditional analogue materials necessary for an upcoming task.

3 Conclusion

As our access to computing resources becomes ubiquitous, we are reshaping the ways in which we interact with each other. Previously unacceptable behaviors are now perfectly acceptable, but new rules of interaction also bring with them considerable communication challenges. We have called for specific design solutions to address these challenges, but the larger implication is that Ubicomp can benefit from a more unified user interface that treats human-computer interaction and human-human interaction as complementary, rather than competing, activities. The emphasis thus far in Ubicomp has been on ubiquity of access. It is time now to move beyond physical access to psychological access. As we graduate from usefulness and usability concerns into incorporating the social context of users [17], their emotions and sense-making while on the go ought to be considered priorities for research and design. We have to recognize that, given the emphasis on communication phenomena in the aforementioned rules, users will need interfaces that feature designs specifically capitalizing on ubiquity of computing access. These interfaces could come in the form of projected walls or body-parts in the future, but the mobile screen is the most dominant interface at the moment. Whatever we design for it, with the rules of Ubicomp, should be transferable to other Ubicomp interfaces as and when they diffuse into society.

References

1. Aguiléra, A., Guillot, C., and Bonin, O. Mobile Phone Use and the Management of Individual Reachability. In Proc. of the COST 298 Project, (2009). http://miha2.ef.uni-lj.si/cost298/gbc2009-proceedings/papers/P062.pdf.
2. Aoki, P.M., Woodruff, A: Making Space For Stories: Ambiguity in the Design of Personal Communication Systems. In: Proc. CHI 2005, pp. 181-190. ACM Press, New York (2005)
3. Avrahami, D., Gergle, D., Hudson, S., Kiesler, S.: Improving the Match between Callers and Receivers: A Study on The Effect of Contextual Information on Cell Phone Interruptions. Behaviour and Information Technology, 26, 247-259 (2007)

4. Banjo, O., Hu, Y., Sundar, S.S.: Cell Phone Usage and Social Interaction with Proximate Others: Ringing in a Theoretical Model. The Open Communication Journal 2, 127-135 (2008)
5. Bardram, J., Hansen, T.: The AWARE Architecture: Supporting Context-Mediated Social Awareness in Mobile Cooperation. Paper presented at the ACM CSCW 2004, Chicago (2004)
6. Berger, C.R., Calabrese, R.J.: Some Explorations in Initial Interaction And Beyond: Toward a Developmental Theory of Interpersonal Communication. Human Communication Theory 1, 99-112 (1975)
7. Chen, B.X.: Always on : How the iphone Unlocked the Anything - Anytime - Anywhere Future--and Locked Us in. Da Capo Press, Cambridge (2011)
8. Clark, H.H., Brennan, S.E.: Grounding in Communication. In: Resnick, L.B., Levine, R.M., S.D. Teasley (eds.) Perspectives on Socially Shared Cognition, pp. 127-149. American Psychological Association, Washington (1991)
9. Consolvo, S., Smith, I., Matthews, T., LaMarca, A., Tabert, J., Powledge, P.: Location Disclosure to Social Relations: Why, When, & What People Want to Share. In: Proc. CHI 2005, pp. 81-95. ACM Press, New York (2005)
10. Davis, S., Gutwin, C.: Using Relationship to Control Disclosure in Awareness Servers. In: Proc. GI 2005, pp. 145-152. ACM Press, New Yrok (2005)
11. De Guzman, E.S., Sharmin, M., Bailey, B.P.: Should I Call Now? Understanding What Context Is Considered When Deciding Whether to Initiate Remote Communication Via Mobile Devices. In: Proc. Graphics Interface 2007, pp. 143-150. ACM Press, New York (2007)
12. Gergen, K.J.: Mobile Communication And The Transformation Of The Democratic Process. In: J. Katz (ed.) Handbook of Mobile Communication Studies, 297-310. MIT Press, Cambridge (2008)
13. Gudykunst, W.B.: Uncertainty and Anxiety. In Y.Y. Kim, W.B. Gudykunst (eds.), Theories in Intercultural Communication. pp. 123-156. Sage, Newbury Park (1988)
14. Gudykunst, W.B., Kim, Y.Y.: Communicating With Strangers: An Approach to Intercultural Communication (4th ed.). McGraw-Hill Humanities/Social Sciences/Languages, (2002)
15. Hampton, K.N., Livio, O., Goulet, L.S.: The Social Life Of Wireless Urban Spaces: Internet Use, Social Networks, And The Public Realm. Journal of Communication 60, 701-722 (2010)
16. Hancock, J., Birnholtz, J., Bazarova, N., Guillory, J., Berlin, J., Amos, B.: Butler Lies: Awareness, Deception, and Design. In: Proc. CHI 2009. pp. 517-526. ACM Press, New York (2009)
17. Höök, K., Isbister, K., Westerman, S., Gardner, P., Sutherland, E., Vasalou, A., Sundstrom, P., Kaye, J.J., and Laaksolahti, J.: Evaluation of Affective Interactive Applications. In: Emotion-Oriented Systems, pp. 687-703. Springer Berlin Heidelberg (2011)
18. Juhlin, O., Engström, A., Reponen, E.: Mobile Broadcasting: The Whats and Hows of Live Video as a Social Medium. In: Proc. MobileHCI 2010. pp. 35-43. ACM Press, New York (2010)
19. Lin, J., Xiang, G., Hong, J.I., Sadeh, N.: Modeling People's Place Naming Preferences in Location Sharing. In: Proc. UbiComp 2010. pp. 75-84. ACM Press, New York (2010)
20. Metzger, M.J.: Making Sense of Credibility on the Web: Models for Evaluating Online Information and Recommendations for Future Research. Journal of the American Society for Information Science and Technology 58, 2078-2091 (2007)

21. Mugge R., Schoormans, Jan P. L., Schifferstein, H.N.J.: Emotional bonding with Personalised Products. Journal of Engineering Design 20, 467-476 (2009)
22. Nardi, B.A., Whittaker, S., Bradner, E.: Interaction and Outeraction: Instant Messaging in Action. In: Proc. CSCW 2000. pp. 79-88, ACM Press, New York (2000)
23. Nielsenwire: Privacy Please! U.S. Smartphone App Users Concerned with Privacy When it Comes to Location. The Nielson Company, (2011) http://blog.nielsen.com/nielsenwire/online_mobile/privacy-please-u-s-smartphone-app-users-concerned-with-privacy-when-it-comes-to-location/
24. Oeldorf-Hirsch, A., Sundar, S.S.: Online Photo Sharing as Mediated Communication. In: Proc. of the Annual Conference of the International Communication Association, ICA, Washington (2010)
25. Odom, M., Zimmerman, J., Forlizzi, J.: Teenagers and Their Virtual Possessions: Design Opportunities and Issues. In: Proc. CHI 2011. pp. 1491-1500. ACM Press, New York (2011)
26. Olson, G.M., Olson, J.S.: Distance Matters. Human-Computer Interaction 15, 139-179 (2000)
27. Parkes, C.M., Stevenson-Hinde, J., Marris, P.,: Attachment Across The Life Cycle. Routledge, New York (1991).
28. Ståhl, A., Sundström, P., & Höök, K.: A foundation for emotional expressivity. In: Proc. of the 2005 conference on Designing for User Experience, pp. 33, AIGA: American Institute of Graphic Arts (2005)
29. Sheldon, O.J., Thomas-Hunt, M.C., Proell, C.A.: When Timeliness Matters: The Effect of Status on Reactions to Perceived Time Delay Within Distributed Collaboration. Journal of Applied Psychology 91, 1385-1395 (2006)
30. Shim, E., Dhara, K., Wu, X., Krishnaswamy, V.: Communication Data Based User Activity Recommendations. In: Proc. ICUIMC 2011, pp. 1-9. ACM Press, New York (2011)
31. Sproull, L., Keisler, S.: Reducing Social Context Cues: Electronic Mail in Organizational Communication. Management Science 32, 1492-1513 (1986)
32. Stephen, W.G., Stephen, C.W., Gudykunst, W.B.: Anxiety in Intergroup Relations: A Comparison of Anxiety/Uncertainty Management Theory and Integrated Threat Theory. Int. J. Intercultural Rel. 23, 4, 613-628 (1999)
33. Sundar, S.S.: The MAIN Model: A Heuristic Approach To Understanding Technology Effects on Credibility. In: M.J. Metzger and A.J. Flanagin (eds.), Digital Media, Youth, and Credibility, pp. 73-100, MIT Press, Cambridge (2008)
34. Sundar, S.S., Knobloch-Westerwick, S., Hastall, M. R.: News Cues: Information Scent and Cognitive Heuristics. Journal of The American Society for Information Science and Technology 58, 3, 366-378 (2007)
35. Traugott, M., Soos, S.-H., Ling, R., Qian, Y.: On the Move: The Role of Cellular Communication Sin American Life: Pohs Report on Mobile Communication. Dept of Communication Studies, University of Michigan, Ann Arbor (2006)
36. Tyler, J., Tang, J.: When Can I Expect an Email Response? A Study of Rhythms in Email Usage. In: Proc. ECSCW 2003, pp. 239-258. ACM Press, New York (2003)
37. Vanden Abeele, M., Roe, K.: White cyberlies: The use of deceptive instant messaging statuses as a social norm. In: Proc. of the Annual Conference of the International Communication Association. ICA, Washington (2008)
38. Vartiainen, E., Väänänen-Vainio-Mattila, K.: User Experience of Mobile Photo Sharing in the Cloud. In: Proc. MUM 2010, pp. 1-10. ACM Press, New York (2010)
39. Woodruff, A., Aoki, P.M.: How Push-To-Talk Makes Talk Less Pushy. In: Proc. GROUP 2003, pp. 170-179, ACM Press, New York (2003)