Ubiquitous computing: Individual productivity at the expense of social good?

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INTRODUCTION

Recent advances in ubiquitous computing provide mobile computing and connectivity that both enable us to be connected almost anywhere at anytime and deliver requests for interaction that compete for our attention. While Weiser's original vision for ubiquitous computing was for computing to become invisible [Weiser, 1991], current trends in the deployment of ubiquitous computing lead to a world where computing pervasively vies for our attention. People are often talking on a cell phone, attending to laptops, poking at PDAs, etc., all while apparently interacting with the real world by attending talks, driving, shopping, conversing with others, etc.

By enabling computing power to migrate outside of the office, our computer interaction has moved from a private context to a more social one. This fundamental change in use context needs to be reflected in the design of ubiquitous computing. Now that these devices and services are gaining widespread use, we are confronting new challenges in prioritizing or sharing our attention in a social context.

One motivation that seems to be driving the development of ubiquitous computing is supporting the productivity of individuals as we move about beyond our desktop computer. Wirelessly connected laptops and PDAs, cell phones, and other mobile devices deliver computing services to anywhere we can access them. These technologies enable us to recover productive time that would otherwise be lost outside of the office, but also introduce multitasking our computer interactions with other activities. Multitasking not only injects tasks into whatever context we are in, but often also affects the people in the social context surrounding us.

Multitasking is becoming part of the social norm, whether it be conducting business over a cell phone while driving kids to an event, working on a wirelessly connected laptop while attending a meeting, or attending to mobile devices (pagers, appointment notifications) that interrupt face-to-face interactions. Currently, there is a bit of social awkwardness when encountering multitasking in everyday interactions,. Can a social perspective help us design more graceful affordances for *socially* managing multi-tasking? This position paper raises concerns about how to design ubiquitous computing technologies to not only support the productivity of the individual user, but also respect the social contexts in which the user is situated.

DESIGN AND RESEARCH ISSUES

Taking a social perspective on ubiquitous computing suggests three salient issues to explore at this workshop:

- Designing for the individual vs. the social context
- Developing a theoretical understanding of human workload limits in multitasking
- Designing for the invisible vs. "in-your-face"

Individual vs. social design

Current trends in ubiquitous computing seem to be designed to support individual productivity without regard to the social impact that they have. While cell phone rings and PDA notifications were designed to get the attention of their owner, their social impact often extends to the surrounding people. The design of notifications for any mobile device should not only be concerned with attracting the attention of the user, but also enabling that user to gracefully negotiate sharing that attention with the current social and other demands on their attention.

For example, two iterations on the design of ringing cell phones show that we still do not have a gracefully negotiated interface. The loud rings of cell phones have had an increasingly annoying social impact, especially in quiet places (churches, theaters, etc.) One adaptation was the introduction of silent ring modes, such as vibrating the device. While this mode avoids the potential audible disruption, it still has socially awkward implications. If two people are interacting face-to-face while one person's cell phone begins silently ringing, the asymmetry of only one person being aware of the potential interruption can still be disrupting. The recipient of an incoming silent call often grimaces momentarily or looks away (toward the phone display) for no apparent reason, and then has to insert an

interruption for which the other person has no awareness of its cause. Contrasting this interaction with the relative ease at which a pair of people can react to the approach of a third person illustrates the difference that a social perspective can bring to designing interactions.

Cell phones also exhibit other properties that can make them "anti-social". Monk et al. [2004a; 2004b] have demonstrated how only hearing half of the conversation and the tendency to speak too loud (due to lack of feedback) make cell phone calls socially annoying. Also, because you typically have to respond to a cell phone call within a certain time frame before it rolls over to voice-mail, responding to cell phone calls takes on an air of urgency that can be especially disruptive to the social context.

And, since callers to cell phone users are totally blind to the context of the recipients, the callers cannot time their calls to avoid inopportune disruptions. Just as I would usually not make a loud approach to someone in a quiet social setting, so could many inappropriate cell phone calls be avoided if the caller was aware of the recipient's context. Recent research has explored novel interfaces for handling mobile phone calls in public settings that provide some textual [Pedersen 2001] or pre-recorded aural [Nelson et al., 2001] negotiation for starting calls.

Designing for the social context means going beyond the user in primary focus to also consider that user's social context. How will this cell phone ring or PDA alert affect the people surrounding the user, especially if she is currently interacting with other people? If a public display changes to respond to one person approaching it, how does that affect the other people currently looking at the display? More research on understanding these social implications needs to be applied to the design of ubiquitous computing.

Designing for human limits in multitasking

The recent deployment of mobile services has imposed multitasking on us without a theoretical understanding of the limits of human abilities in responding to multiple stimuli. While extensive research has been conducted on human workload limits in intense environments such as fighter cockpits (cf. [Karwoski, 2001]), that research has not been applied and extended to deal with similar demands for attention from multitasking in everyday situations.

Recent concern has emerged around the safety issue of talking on a cell phone while driving a car [Strayer & Johnston, 2001]. Research has only begun to explore the broader, more general issue of how people cognitively deal with multitasking and the design implications of those cognitive processes (e.g., [Rubenstein et al., 2001]).

Multitasking behavior is another example where the individual benefits can conflict with the overall social good. Take the example of bringing wirelessly connected laptops to presentations and meetings to be able to continue to process email, respond to IMs, etc. Some view this practice as an unwelcome division of attention, making it harder to have truly engaging meetings due to the partial attention of some participants. Others welcome affording busy executives, who would otherwise not attend, the opportunity to selectively attend in a larger number of meetings. Faced with these opposite reactions, how can we make socially informed design decisions?

Competing notions of whether this distributed attention is good or bad have been raised. Hillman Curtis [2000] mentions the notion of "Multitasking Attention Deficit" as a reason why web motion designers need to communicate their message in ten seconds or less. Parker Torrence [2001] counters with a notion of "Multitasking Attention Dexterity", suggesting a skill to be cultivated through engaging, interactive web design. Linda Stone from Microsoft is credited with coining the phrase "continuous partial attention" [Maxwell, 2002] for coping with the incoming barrage of demands on our attention. Rather than trying to do several things at once by multitasking, continuous partial attention continually scans for the *one* thing to focus on, prompting focused switches of attention.

To help us navigate these competing claims for managing our attention, we need a principled framework to help weigh the individual and social costs and benefits. Basic research on human workload limits is needed to design interactions that do not overwhelm the user. Studies of how people socially deal with competing demands and what cues they need to gracefully coordinate their efforts need to be applied to the design of computer interactions that occur in social contexts.

Invisible vs. in-your-face

Contrary to the elegant invisibility of computing that Weiser initially advocated in ubiquitous computing, the pervasiveness of computational demands is potentially leading to the opposite effect of cramming messages within a ten second attention window. This "in-your-face" nightmare is already realized by the pop-up and animated web advertisements on the desktop computer. Migrating this mindset to mobile devices and ubiquitous computing could have dystopic consequences (as depicted in the movie *Minority Report* [2002] where a cacophony of customized advertising is unleashed when a crowd of people pass by).

We need to return to Weiser's [1994] initial call for involving social scientists to help us understand and design for invisibility. While we manage to negotiate interacting with multiple people at the same time with apparent ease and grace, social scientists have helped provide an understanding of the complex work and awareness needed to accomplish that, so we can design technologies that enter those social interactions (cf. [Luff et al., 1990; Norman & Thomas, 1991]). By contrast, current ubiquitous computing technology tends to barge in to human social interaction like the socially inept boor. We need to apply a social understanding of how people use technology to design ubiquitous computing that respects that social context.

DESIGN APPROACHES

We need to include a focus on the social context of use when designing ubiquitous computing. For example, we need to proactively design for multitasking, rather than just let it happen. Such a design approach needs an understanding of what multitasking is appropriate, both for the limits of human workload, and according to the social context of the user. The design of these systems and services would afford appropriate multitasking and discourage inappropriate multitasking. Several recent research projects explore steps in this direction.

Eric Horvitz et al. [2003] at Microsoft Research have been exploring Attentional User Interfaces. Using statistical probability and decision-theory techniques to draw inferences from a user's behavior, their research aims to balance the expected value of incoming information with the attention-sensitive cost of disruption. These estimates help users manage and prioritize dealing with the incoming stream of attention demands from their desktop computer. One way to extend this work to the social context of ubiquitous computing is to estimate the value and especially the costs for the *social context* (not just the individual) for attending to computer-mediated requests for attention.

James Fogarty et al. [forthcoming] at Carnegie Mellon University have been developing models for predicting interruptibility. By analyzing sensor information on a user's activity, their models can predict times to avoid interrupting the user. A main finding is that social engagement (on the phone, talking with someone else in the office) is a primary predictor for not wanting to be interrupted, demonstrating the importance of social implications of computer-mediated communication. While these predictions can help inform the caller about better times to negotiate an interruption, this work could also be extended to the social context of the user to develop predictions of "social interruptibility". For example, while a person in a theater may not mind getting a call during a performance, the surrounding people might strongly object!

In work that I was involved in at Sun Microsystems, Inc., we explored some of the social implications of temporal rhythms exhibited in work activity. Since there is often regularity in the temporal patterns in people's work activity (e.g., breaking for lunch, recurring meetings), Begole et al. [2004] explored algorithms for modeling those patterns to predict when workers will become available. These predictions often displayed social patterns (e.g., lunch at around noon, weekly group meetings on Mondays).

Tyler and Tang [2003] also studied how people form expectations of when they will get an email response. An observation that demonstrated the social context of email is how people actively managed a "responsiveness image". That is, people would intentionally use the timing of their email responses to present an image of being responsively attentive to important issues or deliberately delayed to unimportant ones. There was broad recognition of paying attention to these social cues, yet it is telling that the design of email provides no support for these social cues. The current design focus on asynchronous messaging overlooks the socially negotiated use of email to convey subtle cues such as a responsiveness image. A socially enabled email service might help users track and manage responsiveness images—both their own to help them maintain their desired image, and others' responsiveness to help predict when to expect email responses from them.

While the examples I have discussed focus mainly on cell phones and web access, their pervasive and mobile use are perhaps the best pre-cursor for actual usage experience with ubiquitous computing. The ActiveCampus project at UCSD [Griswold et al., forthcoming] and the CACM special issue on the Disappearing Computer [Streitz & Nixon, 2005] discuss more recent deployments of ubiquitous computing technologies that raise similar issues. Research on context-aware computing [Moran & Dourish, 2001] has begun to explore how to make use of context to help make computer interactions more useful, and efficient.

Reflecting on these experiences, I think a fundamental issue is determining what cues need to be shared among whom to enable people to gracefully interact. Interactions with ubiquitous computing may be governed not only by the focal individual user, but also the surrounding people in the social context of use. Issues such as determining interruptibility and appropriate multitasking may need to account for preferences of the surrounding people. The example from current research of detecting social engagement to determine interruptibility is only beginning to recognize the importance of the social context. A direction for future research is to explore sharing more cues with those in the surrounding context, and including input from those in that context to shape interactions with ubiquitous computing.

Mobile devices already have many of the sensors built-in that could observe and convey appropriate context for negotiating interaction. Many cell phones and PDAs already have integrated cameras, microphones, and GPS location sensors that could be used to sense the surrounding context. For example, these sensors could readily detect if the owner is currently socially engaged, which could modify how others could establish contact with that owner under those conditions. Furthermore, technology is available that enables exchanging of information among devices that are in close proximity (e.g., my preferences for interaction stored on my cell phone could be shared with your preferences on your PDA to help shape how to handle incoming requests when we are working in proximity).

But more important than what is technically possible is what is socially acceptable. Privacy concerns about electronically sharing information has already evoked sensitive reactions. Any systems that share contextual information need to be designed to be easily and transparently governed by social conventions. Just as we all live with live microphones (telephones) and recording devices (phone answering machines) nearby, powerful

social conventions (and some legislation) prevent them from being used for inappropriate eavesdropping.

One dilemma arises from two possible design approaches to accounting for social context. One approach would be to computationally sense and *infer* the user's social context, and use that inference to shape what interactions are allowed under the current context. For example, if sensors determine that you are in a quiet setting that is sensitive to disturbances, your cell phone might be automatically muted or routed directly to voice-mail. This approach relies on the accuracy of computer inferences, but affords more control of what contextual information is revealed to others.

Another approach would be to sense and *convey* cues so that the people involved would be able to make inferences about appropriate interactions. In the same scenario, if the caller was made aware of the recipient's context (perhaps by getting some preview of it before placing the call), then the caller could realize that a call was inappropriate at that time. While this approach potentially reveals more information about the user's activities, it allows people to make more informed choices about times to interact, rather than rely on inferences from a computer agent. At the workshop, I hope that we can discuss the advantages and disadvantages of these approaches and perhaps synthesize new approaches for designing for the social context of ubiquitous computing.

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