Noncommand Interfaces for Communication Technology in Mobile Settings

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ABSTRACT
Recent advances in technology such as cell phones, email, and online social networks have made long distance communication faster and easier than ever before. These advancements facilitate communication across both long and short distances and allow for social affordances [1] that in the past have been hard to capture. These new communication technologies are often used in mobile settings for sharing both explicit and implicit information with family, friends, and strangers. The choice of what data to share and how to allow users to send and receive data can make a large impact on how users interact with the technology and with each other.

This paper compares different approaches for designing mobile social communication technologies that create a sense of awareness and connectedness [2] between their users.

INTRODUCTION
Communication has always held a place of high value in societies and is often one of the first priorities of a civilization. Prehistoric peoples relied on cave painting and carvings to communicate their knowledge and stories to future generations. Ancient Romans focused on building a series of interconnected roadways that allowed for not only improved trade, but also improved communication routes allowing for the Roman Empire to exceed the size of any of its predecessors. Much later, early Americans implemented the Pony Express to connect physically distant people with a speedy mail system. Finally, with the invention of the telegraph, and later the telephone, synchronous long distances communication was for the first time possible; opening the door to modern communication technologies such as email and mobile phones.

Rich communication technologies have often been viewed as the Holy Grail for human connectedness with Arthur Mee saying in 1898

“There is, indeed, no element in our social life which will be unprovided for, and if, as it is said to be not unlikely in the near future, the principle of sight is applied to the telephone as well as that of sound, the earth will be in truth a paradise, and distance will lose its enchantment by being abolished altogether. [3]”

Modern technology has advanced to a point where we might expect to see this “paradise” where “distance has lost its enchantment”. In truth though, there still seems to be something lacking. What have we been missing?

The goal of much of the recent research addressing social communication across physical distance often focuses on providing users with a sense of awareness and connectedness [2]. In this context awareness refers to “the state of knowing about the environment in which you exist; about your surroundings, and the presence and activities of others” [4] where “others” can refer to both those physically proximate, and those physically distant. The term connectedness refers to “a positive emotional appraisal which is characterized by a feeling of staying in touch within ongoing social relationships” [5]. Although awareness and connectedness are often observed together, awareness does not implicitly cause feelings of connectedness and the presence of feelings of connectedness does not necessarily imply awareness. For example, seeing statistics from the national census increases awareness of the activities of others but is not likely to incite feelings of connectedness towards the people recorded in the census.

These trends towards focusing on awareness and connectedness have caused a push away from rich but heavyweight synchronous communication choices such as video phones, towards low-bandwidth and lightweight communication methods that are more continuous in nature. This new family of communication technology integrates the many of ideas found in noncommand based interface and applies them to the mobile communication space. Implicit communication between users is made possible by leveraging data collected by sensors to facilitate a passive communication model that is similar to collocated human communication behavior.

In this paper I will first motivate why focusing on awareness and connectedness is important for designing future mobile communication technologies. I will then compare several existing mobile application approaches where noncommand and lightweight interfaces have been used to facilitate the sharing of data to promote awareness.
and connectedness. I will conclude with a look at future directions and potential application spaces.

MOTIVATION
Awareness and connectedness may seem like a strange starting point for designing computer systems. However, once we begin to look more closely at the situation we can begin to see that human factors actually play a huge part in the overall design of a system. Take for example, the constraints imposed on a mobile system by technological limitations and human limitations.

Constraints imposed by Mobile Technology
Designing for the mobile space has certain limitations that persist regardless of the motivation behind the technology.

- Battery power must be depended upon as a primary power source and therefore must be used wisely
- Some technologies do not work in certain environmental contexts. For example GPS does not work inside buildings or in densely developed urban areas.
- Screen size is limited to device size, limiting how much information can be visually displayed.

Constraints imposed by Mobile Humans
We must also take into account what types of technological limitations are introduced by mobile users

- In many mobile situations it is inconvenient or even dangerous for the user to receive data from the mobile device visually.
- Often times interacting with a mobile device is not the primary task of the user.
- The context of the user is often changes raising questions about how to notify the user in an appropriate fashion.
- Devices must be small enough that they can be easily carried by users.

This division into two distinct categories is important because it allows us to see which constraints we can expect to change in the future, and which constraints we can expect to be more consistent over time.

With the technology constraint examples listed here for mobile devices it is not too unreasonable to envision future solutions. Research in battery technology is ongoing and there are also alternative energy sources such as sunlight and human movement. Augmenting GPS with 802.11 signals and cell tower triangulation can get reasonably good location results while indoors, and even screen size limitations can be overcome with miniaturized projectors or flexible electronic paper.

In contrast, when we start looking at the constraints imposed by humans, solutions to the imposed limitations become much less obvious. There is even a reasonably good argument that these limitations are not problems that should be solved at all. The fact that the users eyes are not always available to interact with the mobile device does not mean that we should find a way to force the users to make their eyes more available. These human imposed constraints are a large motivating factor in how communication technologies are designed and they often are what drive which solutions we find to solve the technological constraints.

Awareness and connectedness similarly affect the direction of technology because they fulfill a basic human need. It is not the case that every mobile technology should cater to the human needs of awareness and connectedness, but it is inevitable that some will, creating a need for capable technology. The only way to fulfill human needs without violating human constraints is by using both to design solutions to the more flexible technological constraints.

DESIGN
When designing communication technology for the social needs of humans, certain design decisions must be made either purposefully or through tacit inclusion. These design decisions shape how the users interact and relate to both the system, and other users.

Ideas for Design Targeting Social Mobile Needs
Certain design principles can help guide the design of new technologies. Keeping these principles in mind can help the designer to think “outside of the box” to create novel technologies that do more than mimic existing technologies.

Noncommand User Interfaces
In his paper “Noncommand User Interfaces” Jakob Nielson introduced the concept of noncommand based user interfaces.

“All previous generations of UIs whether batch-, line-oriented, full-screen, or WIMP, have all had one defining characteristic in common: they were all based on the concept of an explicit dialogue between the user and the computer during which the user commanded the computer to do something. Indeed, the concept of commands has become so ingrained in the design of all previous interface generations that many people may not have considered that it is a design decision to include commands at all.” [6]

These interfaces are distinct from other interface types in that they do not use explicit user action to affect change in the computer. A good illustration of this is the example of the act of moving an item on the screen that is obscured by another item.

Function Oriented UI: Function oriented UIs use verb-noun structured commands to first declare an action and then what the action should be performed on. In this case “move item”

Object Oriented UI: OO is the backbone of most windowed applications. Here the structure is a noun-verb combination where the choice of object constrains which actions are possible to call. This removes a wide range of possible syntax errors that are possible with the function oriented model where functions can be called on incompatible types. In our delete example the user would first select the item
and then select “move” from that object’s list of possible commands.

Direct Manipulation UI: In direct manipulation interfaces we see the user interacting directly with object to perform tasks. Here we could expect that the user would select the item by clicking on it and then drag it to the desired location.

Noncommand UI: In a noncommand user interface the user is not required to do anything. The computer would notice the obscured item and move it out from behind the other item so that it is still available to the user.

There are several advantages to noncommand interfaces that make them appealing. The first is to present users “natural” interfaces that requires minimal learning. Here a “natural” interface is one that builds on “abilities that many humans have historically acquired anyway (such as looking at the world, hand writing, or gesturing)” [6].

The second benefit of noncommand user interfaces is that they allow the user to focus on their task, rather than focusing on how to manipulate the computer. In the ideal noncommand interface the computer is a completely transparent entity and the user’s focus is wholly on their task.

In the mobile context noncommand interfaces hold special appeal. Mobile devices such as cell phones are notoriously hard to navigate due to their tiny keyboards and small screens. If we can eliminate the need for users to rely on commands to get value out of their mobile devices for even a fraction of their mobile needs it would be a great advance.

_Ubiquitous Computing_

In the paper “Some Computer Science Issues in Ubiquitous Computing” Mark Weiser states:

“Ubiquitous computing enhances computer use by making many computers available throughout the physical environment, while making them effectively invisible to the user.” [7]

This description presents obvious parallels with Neilson’s noncommand user interfaces. Probably the strongest parallel is that both place high value in the concept of the computer fading into the background, ultimately allowing the user to benefit from the power of a computer without feeling as if they are interacting with a computer. To really achieve this sense of computer transparency it is likely that some level of integration of noncommand user interfaces with ubiquitous computing devices is required.

The general idea behind Ubiquitous Computing is moving towards a world where computers are always available to provide users with assistance, preferably in a natural and non-intrusive manner. In Weiser’s example of an office benefitting from Ubiquitous Computing there were three classes of ubiquitous technology; the Tab, Pad, and Board. The idea idea is to have many instances of the small and inexpensive “Tab”, slightly fewer instances of the larger book-sized “Pad”, and only a couple instance of the large wall-mounted “Board”. In the setup presented by Weiser there is an element of mobility, but it is limited to within an office building.

To achieve this level of ubiquitous computing in a truly mobile way, one can imagine the multiple Tabs and Pads being replaced by cellular phones and laptops which many people carry with them on a regular basis anyway. To translate the concept of boards to a mobile environment the installation of interactive public displays would most likely be necessary. Even in the absence of the large scale displays it is likely that a highly integrated mobile computing environment can be experience with just the smaller two device sizes.

_Gift-Giving_

When designing for mobile communication research it is also important to consider how existing human practices will likely affect how users interact with the device. The social phenomenon of gift-giving is long standing in the physical world, and it has a strong impact on how humans relate to the sharing of digital data [8]. In a study of the sharing of intangible digital data in teenage friend groups Taylor and Harper found that the same rules that govern the gifting physical gifts apply to the sharing of digital data. Perhaps the most important parallel found between digital and physical gift giving is a phenomenon referred to as social reciprocity.

“This system of reciprocity allows people to employ the tangible in a way that binds them through unspoken contracts.” [9]

This system generally leads to the recipient of a gift feeling social obligated to repay the gift giver. Often this is manifested as the recipient bestowing a gift of similar value upon the original gift giver. The gift giver, as a result of their giving, takes a position of power while placing the recipient in a position of inferiority. If receiver decides contribute equally in this exchange, the power balance is restored and an enhanced sense of connectedness between the two participants is often achieved. In contrast if the recipient refuses to reciprocate, or due to circumstances is unable to reciprocate the power balance is not restored and feelings of hostility and rivalry are often felt by both parties [10].

In a study of the social mobile habits of teenagers, Taylor and Harper observed a similar system of obligation between users regarding the sharing of digital artifacts such as text messages [9]. Teenagers assigned value to messages depending on content; where private personal messages were deemed the most valuable, and public impersonal messages were deemed the least valuable. The mode of message receipt also attributed to the value of the message with messages sent from free online text messaging services
being viewed as less valuable than messages sent from a handset.

Similar observations of digital gift-giving were also seen by Kaye in his study of low-bandwidth Virtual Intimate Objects (VIO) [11]. The VIO project allowed for long distance couples to indicate when they were thinking of their partner by clicking an icon in the taskbar on their desktop. In response to the click, a corresponding icon on their partner's screen would glow red and slowly fade over time to visually indicate that their partner had been thinking of them. In this example the act of clicking the icon can be seen as an act of digital gift-giving. Interestingly, despite the minimal action required to click the icon, the users attributed value to the action and reported feelings of reciprocal obligation leading to a phenomenon they termed "Clickwars".

These examples of digital gift-giving provide two important thinking points for designers of social mobile technologies. The first is that providing recipients of data a means of "reciprocal gifting" with data of equal value is crucial to maintaining power balances and facilitating a sense of connectedness between users.

It is important to note that there does not seem to be a minimal boundary for what is perceived as gift-giving. As we see by Kaye’s findings, even a simple mouse click can cause the recipient to feel obligated to reciprocate. If one user exerts any effort at all to intentionally provide content to another user it seems the system of reciprocity will apply.

**Implications of Design Choices**

Understanding the implications of different design decisions can help inform the design of new mobile technologies. In this section we observe different design methods and discuss the results of these choices.

**Implicit and Explicit Sharing**

There does seem to be one escape from obligation of reciprocity, and that is in the implicit sharing of data. When we take a closer look at the digital gift-giving scenarios it becomes apparent that in each case the digital data or "gift" was the result of an explicit action of the sender or "giver". The question then becomes is the data perceived as a gift, and thereby fall under the ancient social rules of gift-giving, as a result of that explicit action.

We can use noncommand interfaces as our model for implicit data sharing. In a noncommand based communication the sharing of data is a side effect of a user action rather than the result of an explicit action. Automatic data sharing brings with it an entirely different set of social guidelines as the concept of reciprocity makes little sense in scenarios where a sender may not even be aware that she has shared data with her partner.

An example of a system which uses implicit interactions to facilitate a sense of connectedness is the SyncDecor project [12]. In the SyncDecor study linked physical objects were placed in the homes of couples in long distance relationships. Four different synced objects were placed in homes including a lamp, a trash can, a television set, and an aroma pot. When a participant interacted with an object, for example turning on the light, the distant object would also respond, in this case causing the remote partner’s light to also turn on.

SyncDecor found that through daily interaction with synced household appliances couples were able to share information about their daily routines without exerting any additional effort. This type of communication is unlikely to initiate feelings of obligation for reciprocation because there is no guarantee of message receipt and messages are implicitly sent as a byproduct of daily behavior.

Explicit and implicit user interaction can be implemented on both the sender side and the receiver side of the communication. SyncDecor is an example where both sides of the communication are implicit, but one can imagine systems which are implicit on delivery and explicit on receipt or vice versa. One example of explicit sending and implicit receiving in modern social media is in Facebook status messages [13]. When a user types in a new status message they must do so explicitly, but no explicit messages are sent to the user’s friends to indicating the update. Instead friends may happen across the new status message through the course of their regular browsing behavior on the Facebook website, or they may never see it at all.

In contrast the commercial location sharing application Loopt [14] allows for implicit sending and explicit receiving. In this case a user’s location is implicitly shared, and can be viewed by others when they request it through explicit action.

The choice to use implicit or explicit interaction methods will affect what technological decisions are made in the design of a system. In implicit communication systems information that was once provided by direct human interaction must now be supplemented with collections of sensors. In the mobile setting these sensors must have low battery consumption, be small enough to be incorporated
into a small device, and be robust enough to not break when jostled or dropped.

*Methods for Information Receipt*
Humans receive all their information about the world via the five senses: sight, sound, taste, touch, and smell. Therefore, it is safe to say that we are limited to these input mechanisms when we decide how a technology will deliver information to a user.

Sight is by far the most prevalent method of delivering data to users on modern devices. Visual communication has many advantages, such as the ability to display both text and images. The discreet nature of the visual channel is also a benefit, as information can be delivered to a user without alerting others in the vicinity. These advantages have made visual displays the medium of choice for delivering information in the traditional computing context.

Unfortunately, relying on sight in the mobile context highlights the weaknesses of the visual sense. Screens on mobile devices are small and limited by device size, which is ultimately limited by how large of a device users are willing to carry around. An even greater downside of using a visual interface for data delivery is that it requires that the device be in the user’s field of vision. The once safe assumption that the user’s eyes are always available rapidly breaks down when we start to look at mobile technologies. Many users carry their mobile devices in the pockets or purses making it easy for them to miss a visual cue. Advances in wearable technology, such as augmented glasses or goggles, may make visual data more reliable in the mobile setting at the cost of requiring the user to wear an additional device.

Audio is the gold standard for reliable data delivery in mobile settings. The audio channel can support anything that can be played by a speaker including voice, music, and notification sounds such as beeps or dings. In addition to being able to portray a rich variety of information the audio channel has the added benefit that the user need only be in the vicinity of the device to hear an alert. This may benefit the mobile user because although mobile devices are rarely in the users field of vision, they are nearly always within hearing range of the user. However, this advantage is also the inherent downside of audio. There are many situations where using the audio channel is inappropriate because others in the vicinity would be bothered. Headsets seem to be the obvious answer to the problem of noise pollution. However, headset wearing introduces additional problems by obstructing the wearer’s ears, and making it hard for them to hear their immediate surroundings. Recent advances in bone-conduction headsets may be able to help alleviate these problems by delivering sound directly to the user’s skull [15].

Haptic interaction allows for the users to receive information through touch. Haptic interfaces offer an alternative to visual and audio interfaces that is both subtle, and available when the device is no in the user’s field of vision. The downside of haptics is that to get these benefits one must either sacrifice richness of data, or ease of adoption. To convey complex data using haptics, a system similar to Morse Code can be implemented to convey data, at the cost of greatly increases the barrier of entry [16]. In contrast, most users can understand simple messages from a small fixed vocabulary without training [17].

Taste and smell seem to still have limited applications and appear to be the hardest to implement. There are several communication technologies that use smell such as SyncAroma [12] which releases the scent of a distant loved one, and MeetingPot [18] which releases a coffee aroma to indicate when people in an office are taking a coffee break. Taking these interaction methods into the mobile space may pose even more problems since it may be awkward to have a device in your mouth in public, and using smell may bother those around you in a way that is more subtle, yet more persistent than audio.

When choosing which interaction method to use in a new technology there are two needs that need to be balanced. The first is the urgency of the information that is being delivered, and the second is how much disturbance is acceptable to the user and those in the user’s vicinity. In the case of very urgent information, such as a device that alerts you to a loved one’s heart condition, it may be wise to sacrifice disturbing the user because the cost of missing such information is quite high. However, if the purpose of the application is to share what food you are eating it may be better to pick a more subtle from of data sharing since the information is of the “nice to know” sort. In many cases a combination of approaches may be appropriate where either the device automatically detects user context and determines which delivery method is appropriate, or the user manually sets the mode as they move between different settings.

**TAKING IT MOBILE**
This next section focuses on a collection of mobile applications designed to facilitate awareness and connecters in a ubiquitous environment. A common aspect of many of these applications is a focus on location based information sharing. This is probably an artifice of these being the first projects in a relatively new area of mobile personal sensors for communication. Location is an obvious candidate for data sharing because standard cell phones come equipped with the ability to read cell tower IDs and often come with WiFi capabilities, both of which can be used to determine location and movement using various techniques such as triangulation and motion algorithms. We can expect that as this area matures that a greater variety of sensors will be integrated into mobile communication application design.

Some aspects to keep in mind while looking at each of these examples are

- Symmetric or Asymmetric Sharing—is the sharing of data symmetric between users or is one user the sender of information and the other the receiver of data.
• Symmetric or Asymmetric power relationships between study participants—is the power relationship equal, or do some people in the study have power over others in the study. For example a group of friends will most likely have a symmetric power relationship, while a family with children will likely have an asymmetric power relationship.

These two factors affect how data can be shared between users and what data should be shared between users.

**PeopleTones**

An example of symmetric automatic location sharing technology is PeopleTones, a system for sharing buddy proximity within a defined social group [19]. The basic idea behind PeopleTones is to provide mobile users with an indication of when their friends are physically close to them. PeopleTones does not directly facilitate user interaction beyond automatic proximity sharing, although study participants often acted on the proximity information on their own.

**Sensors**

Cell phone towers are used to discover buddy proximity and a special proximity ratio is used to determine whether each buddy is “near” or “far”.

$$\text{proximity. ratio}(a, b) = \frac{|a \cap b|}{\left(\frac{|a| + |b|}{2}\right)}$$

Here \(a\) and \(b\) represent the sets of cell towers seen by two different phones. The ratio ultimately chosen to indicate proximity was four; with less than four being far” and four or more being “near”. The choice of ratio used in PeopleTones was based on the need for high levels of accuracy without a requirement for high recall. Accuracy is the need for a low number of false-positives, while recall indicates what percentage of true-positives were sensed. Because PeopleTones conveys “nice to know” data to users it is appropriate to construct the proximity ratio such that a lower number of false-positives are reported even if it results in a higher number of false-negatives.

In addition to the proximity ratio PeopleTones uses a two-bit counter to determine when to change a user’s status from “near” to “far”.

Figure 2. Two bit counter for changing user status between “near” and “far” [19]

This two bit counter smooths out transition period where a buddy’s proximity ration hovers around four and reduces the chance that there status will switch back and forth between near and far.

PeopleTones also uses the phone’s microphone as an additional sensor. Users can select to use the automatic noise detection feature which uses the amount of ambient noise to decide how loud an alert should played. Users can also select to have PeopleTones use the phone’s ringing profile to determine what level of volume to use. Either audio, vibration, or a combination will be played to indicate buddy movement depending on the user’s context. When a vibration setting is selected a vibration that has been generated from the sound clip is used in place of the sound clip.

**Information Receipt**

The PeopleTone system uses audio and vibrotactile cues to indicate when a user’s buddy moves from “far” to “near”. Each buddy is associated with a particular song or nature sound so that when the user hears that song or sound they know which buddy had moved near them.

In addition to the sound and vibration indicators, users are also able to view their buddies location status by entering the application on the phone and viewing a friends list.

**User Perception**

The PeopleTones user study consisted of three friend groups sized 4, 5, and 8. Study participants reported feeling more connected to fellow users during the study due to increased awareness of their friend’s whereabouts. The application design enabled discovery of their friends movement patterns that would have been difficult to discover without the automatic delivery of buddy proximity information. One example of such an interaction is illustrated by the following user quote.

“One time at the library, I wanted to eat with someone and so I went outside to call someone. The phone vibrated. I just called the person to meet up.”

Here the user expresses that due to the low barrier of discovery they were able to take advantage of an opportune meeting that they otherwise would have been unaware of.

**Reno**

Reno is an example of a technologically symmetric location and activity sharing application designed to allow for both automatic and manual disclosure [20] [21].

The purpose of the Reno system is to allow families to stay in touch using a request response structure. Users can request the location of other users and the requested user can manually respond, or if desired, the user can use automatically generated location responses.

**Sensors**

Reno uses cell towers to compute mobile phone location. To allow for Reno to make use of absolute location the researchers used wardriving techniques to link cell phone tower signals with physical locations. These datapoints allow Reno to determine the absolute location of the device.
using triangulation. This information can then be used to automatically share a user’s location, or to provide a list of suggested locations when the user selects the manual sharing mode.

**Information Receipt**
Reno uses both sound and vibration alerts, and uses the phones profile setting to determine which type of alert to present to the user. When the user is not in automatic sharing mode, these alerts prompt the user that further action is required with the phone’s visual interface. Once in the interface the user can choose to reply from a list of suggested locations or type in a more specific answer to send back to the requester.

**User Perception**
Reno’s user study consisted of two family groups, both with teenage children. The choice of family groups makes the use of Reno significantly different from the PeopleTones user study due to the hierarchical power structure between parents and children.

To accommodate the asymmetric power balance Reno was designed to allow users to lie about their location to others. One example observed in the study was when a teenage child was asked separately by a friend and his parents about his current whereabouts. The response sent to his friend indicated he was relaxing, while his response to his parents suggested he was studying.

While Reno is not a true non-command communication interface it does benefit from many similar ideas, creating what is known as a “lightweight messaging”. Lightweight messaging helps users stay in touch by allowing them to easily share non-critical information. In the absence of such an application users will often choose not to share information to avoid “bothering” other users with non-critical information such as location status. Reno provides an interface where the sharing of this non-critical data is accepted and valued.

**Connecto**
The Connecto project shares user’s location, the length of time user has been at a location, and the phone’s current ringing profile within a defined social group [22]. Users are able to “tag” locations as they move throughout their day giving each location a name. When they later return to that place their location status will update to show the name associated with that location tag.

**Sensors**
Connecto uses cell towers “fingerprints” to determine a user’s location. These fingerprints consist of the set of cell towers that are visible at a particular location and have an accuracy range of 94 meters and 270 meters depending on geography and tower placement. Connecto allows for users to refine their location points by tagging the same location on multiple occasions. This allows users to increase the size of a larger location, or provide more cell tower data if a particular location is covered by many towers. Locations are considered a match when 60% of the towers currently seen match the towers associated with a location tag. If more than one location scores above 60% the location with the highest match is chosen.

*Figure 3. Connecto interface showing location, time, and status information for each user. [22]*

**Information Receipt**
The Connecto interface does not makes use of explicit alerts. Instead Connecto relies on an ambient visual interface to share information between users. In this case the cost of users missing a friend’s location information was low, while the cost of disturbing the user with too many location updates was high. Therefore, due to the nature of the information being non-critical, researchers made the choice share it using the less available visual interface on the phone.

**User Perception**
The most interesting result from the Connecto user study is how quickly users moved from activity sharing to story telling.

As the study progressed users began to edit their phone profile to contain more detailed accounts of their activities. A “meeting” profile might turn into “in a boring meeting” and “driving” might become “stuck in traffic”. These additional details allowed users to use story telling techniques instead of just relaying straight facts. These finding show that there is user interest in sharing data beyond pure sensor data.

**Motion Presence**
Bently and Metcalf suggest a very different approach to location sharing between couples and friend groups in their Motion Presence application. Instead of sharing location information, the data that is shared between participants is purely motion data. [23]. The idea is that each user has access to a list of their participating friends, and next to each name the corresponding status will read either
“moving” or “not moving” along with how many minutes they have been in that state.

**Sensors**
The Motion Presence application uses cell tower signals in combination with the algorithm developed by Laasonen et al. [24] for determining motion. When a phone is stationary it will adopt a cell tower handoff pattern with the towers in the vicinity. To determine motion, researchers implemented a system that keeps track of all the tower viewed by the phone in the past fifteen minutes. When the phone encounters two new cell towers within five minutes that were not seen in the past fifteen minutes the phone is considered to be moving. This algorithm does increase delay in motion sharing since cell towers often cover broad regions and the user may be in motion for some bit of time before they encounter two new cell towers. This also means that only motions large enough to cause the user to encounter new cell towers will be reported as motion events to other users.

**Information Receipt**
The data shared through Motion Presence is similar in nature to the data shared in Connecto. Therefore, not surprisingly, Motion Presence takes a similar approach to user notification. Mobile Presence makes use of an ambient visual display on the phone screen which lists the user’s friends with their corresponding motion statuses. Whenever a user changes state their phone sends an SMS message to the phones of the other users indicating the need for a status update.

The motion presence application is also allows participants to call or text message directly from the motion status interface. All communication between users was documented and time stamped for the purpose of later data analysis.

**User Perception**
Participants in the Motion Presence study reported that they used the motion information in combination with time context and their knowledge of their friend’s schedules to speculate about their friend’s location and activity.

Motion information was used in a variety of ways by participants. One common use of motion information was for communication purposes. For example, when a participant saw that her partner was moving she called him to ask that he pick up milk from the grocery store on his way home. Motion presence also fostered a sense of connectedness between users, both from just being aware of each other’s status and from the visual reminder of the other person’s presence. Users reported looking at the application when they missed their partner and reported feeling a sense of connection even when they were separated.

**Whereabouts Clock**
The Whereabouts is an asymmetric location sharing application that displays the location of family members on a clock style device within the home. [25] The Whereabouts clock is designed to be significantly less expressive than other location sharing applications in that it limits user sharing to four predetermined location categories; “home”, “work”, “school”, and “elsewhere”. To supplement this limitation the Whereabouts Clock allows users to augment their locations with short text snippets which can be viewed when a user touches a family member’s photo on the clock.

The clock is implemented using a pressure sensitive Tablet PC to allow users to interact with it without requiring additional tools. The tablet computer is housed inside a wooden casing to encourage users to view it as a household object rather than just another computer screen.

Figure 4. The Whereabouts Clock interface is divided into four sections. The three sections in the outside ring are labeled “home”, “work”, and “school”, while the center region represents “elsewhere”. Small circles containing photos represent each user. [25]

**Sensors**
The mobile aspect of the Whereabouts Clock is implemented on Windows mobile smart phones, and location data is shared automatically between the phones and the clock. Location data is gathered by using the cell tower id capability available in the phone. When users first receive their device they are required to register each location on the phone. There is no need to know the absolute location of the cell towers which lowers the initial setup costs of deploying the application.

**Information Receipt**
Due to the asymmetric data sharing setup in the Whereabouts Clock project, the receiver and the sender only exchange information one way. The senders of data are the family members that are carrying mobile devices either in or out of the home. However, receivers are only
those currently in the home in view of where the “clock” is on display.

The Whereabouts Clock’s position as an ambient home display is in many ways far superior to the visual mobile interfaces used in both Connecto and Motion Presence. Perhaps the largest benefit of an in-home display is that it is always in plain sight. When compared to a mobile display which often turns off to conserve power and is frequently tucked away in pockets or purses, this is an obvious advantage. A second benefit of the clock design is that the display size is not limited by needs for mobility allowing for greatly increased visibility.

An additional benefit of being located in the home is that because the physical location of the clock does not change indicators such as audio cues can be used without worry about inappropriate context. These audio features are implemented to alert those in the home to when a new message has been received from a family member. When the clock receives a message it plays a cuckoo clock noise and displays the first few words of the message rotating around the photo of the user who sent the message. A user near the clock can then retrieve the full message by touching the photo. The clock also chimes when a user moves from one location to another.

These benefits allow for the Whereabouts Clock to be effectively used in a home environment, but they do come at a cost. By situating the clock display in the home, users traveling outside the home do not receive any additional information about other users by using the device. Only those who are situated inside the house can benefit from the location sharing features of the Whereabouts clock.

**User Perception**

Participants in the Whereabouts Clock user study consisted of five families, totaling 26 people in all. In-home deployments lasted from 4 to 9 weeks and all the selected families consisted of both parents and children.

Researchers categorized users experience with the whereabouts clock in three main categories: coordination, reassurance, and connectedness.

Coordination with the Whereabouts Clock came in two varieties. The first was explicit communication that generally came via the messaging system. Users would often send messages to let their family members know that they were delayed in traffic or stuck in a meeting. The second observed coordination use, referred to as “put-the—kettle-on” coordination was when a family member would happen to notice that a family member was on their way home and would do something in preparation for their return, such as putting a kettle on for tea. In this second situation the mobile user is not even aware that their family member has noticed their movements until they arrive home to a warm cup of tea.

Users of the whereabouts clock also expressed that it provided a sense of reassurance. While family members had no reason to believe that their loved ones had not reached their destination safely, they still reported that the clock provided an additional sense of peace by validating their beliefs about their loved one’s locations.

Study participants also reported that the clock facilitated a sense of family togetherness with users saying thing such as “It just keeps you that little bit closer all the while.” The clock provided a visual reminder of family togetherness and participants reported enjoying viewing the clock even at times when all family members where home, because of the visual reminder that they were all home together as a family. That the clock was viewed as useful even when all family members where home is an interesting finding, because it indicates that users place value in both the utility of the clock as a coordination and reassurance tool, but also that they value the feelings of connectedness promoted by the clock.

**DISCUSSION**

These examples cover a range of techniques for the communication of non-critical information between users in a mobile setting. As previously discussed, the majority of these applications focus on the sharing of location information between mobile users. This is most likely due to the fact that location data is easily supported by technologies already present in modern cellular phones. Additional sensors are now making their way onto mobile phones such as the iPhone’s light sensor and accelerometer, while should open the door to more varied sensor based communication.

An observation that can be made over these technologies is that even though most were limited to location sharing information, users found greater value in the applications that extended beyond just knowing where the other users were. What came out of the location sharing studies is a window into what information users are really interested in sharing. The safety of others was a common theme across nearly all the applications although it was found more strongly in user studies that use families instead of friend groups. The ability to have a constant connection with others was also viewed as a valuable trait, with users often just looking at the applications to feel “connected” with the other users. This indicates that even low bandwidth connections between users can be valuable when they allow users to feel continuously connected with one another.

These observations about how integration of sensors with mobile technology fit well with Nielson’s description of the disappearance of turn taking in future noncommand interfaces. While the turn taking described by Neilson refers specifically to the dialog between humans and machines and is focused on the single user case; when we look at computers as a communication bridge between two or more humans we can also apply his concept of noncommand based interfaces to noncommand based communication. In our nontechnical lives we see this kind...
of communication all the time. Human communication is rich with non-explicit communication, and humans are adept at learning about the states of those around them through implicit cues and actions in the periphery.

It fits then, that the future of noncommand based mobile communication is intertwined with the concept of continuous communication. In continuous communication we start to see turn taking disappear, creating a form of interaction that is closer to how collocated humans interact. This is not to say that turn taking will disappear completely, more that turn taking will continue to take place in situations where it makes sense such as a phone conversation, and continuous communication technologies can step into situations where turn taking is an unnecessary burden or even a danger, such as trying to discover if a loved one is still in the office or if they are driving on the freeway.

**Noncommand Based Interfaces with Implicit Peripheral Awareness**

As mobile sensor technology matures we can expect to see an increase in what kinds of data users can share. However, part of using these sensors is deciding what to do with the data that is collected.

Take for example a phone with a light sensor and an accelerometer. The phone probably came equipped with a light sensor so to allow for automatic adjustment of screen brightness, but it could also be leveraged to learn whether the phone is out in the open or is inside a purse or pocket. Accelerometers are commonly included in mobile devices to allow easy switching between landscape and portrait display on the screen. However, an accelerometer could also be used for a variety of other uses such as a motion detector or even as an input device.

Most sensors can be used in a multitude of way to collect very different sorts of data. The important choices in the future will be how to leverage sensors, and combinations of sensors, to extract the data that is most valuable to the user.

**Delivery Methods**

As sensor technology progresses and the amount and types of data available for sharing increase, the old methods for delivery will soon become overloaded. The human brain is capable of efficiently processing many different sources of data at once, but our ability is very dependent on how the data is presented. For example, the task of crossing the street depends on many different methods of data delivery for success; such as correct processing of all visual and audio input, as well as the physical sensing of the road. Similarly, to successfully share multiple data source between users using mobile devices it will be necessary to design interfaces that can “fade” into the background, ideally as easily as our natural senses do when we cross the street. This means that new and creative methods need to be developed to address data delivery needs as the current solution of cramming more information onto a tiny and seldom available phone screen probably is not the answer.

**Vibrotactily Enhanced Mobile Devices**

In the PeopleTones project we get a glimpse of how vibrotactile communication can be used in a mobile setting. This method is perhaps the one that is most achievable in the short term since vibration motors already come standard in current cell phones. Future directions with vibrotactile technology will include researching how well humans can differentiate between vibration patterns and how many distinct patterns can be recognized with high precision. Full languages, such as Morse Code, can also be represented using vibrations so that more complex messages can be sent between users at the expense of a higher learning curve.

**Augmented Clothing**

Another alternative method of mobile information delivery is augmented clothing. One example, called Stress OutSourced from the MIT Media Lab, gives us an idea of what clothing augmented for communication might look like. [26]

![Figure 5. SOS jacket design prototype. Massage modules are organized in "zones" where massages from those physically close to you are closer to your spine (in zone 1) and massages from users distant from you are farther from your spine (zone 2 for same country, zone 3 for same planet) [28].](image)

The Stressed OutSourced jacket is designed to deliver massages to the user when they are experiencing stressful situations. Technology is not quite to the point where mobile stress sensors can be incorporated in the jacket, so a stress signal button is attached to the sleeve to allow user to signal stress. Receivers of a stress signal can respond by pressing a similar button in their sleeve to send a soothing massage to stressed user. These massage panels are sewn in an array on the back of the jacket and provide the user not only with massage, but also information about how many people responded to the request and how far away the responders were.
When compared to augmenting mobile devices like cell phones, clothing has both advantages and disadvantages. One advantage is that clothing is a much more dynamic medium than cell phones and is generally continuously available. A disadvantage to clothing is that while users can be depended upon to carry the same mobile device with them every day, the same assumptions cannot be made about clothing. Therefore, to make augmented clothing a viable option in the future, designing for easy application and removal of the communication technology may be critical.

CONCLUSION
Supporting low-bandwidth continuous communication in mobile environments is valuable to users and will have significant interface challenges in the near future. As more sensors become available in the mobile environment, the ability and desire to share data between family and social groups will increase.

As we see from the current research in the area “small news” is appreciated and creates a sense of awareness that promote feelings of connectedness among users. Small news also contributes to a sense of wellbeing among users as it provides an indication those one is connected to are physically safe and that “people are where they ought to be and things are as they should be”.

The challenge now is the designing of delivery techniques that will provide communication information to mobile users in a way that is lightweight but easily internalized by users.

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