Because I Carry My Cell Phone Anyway: Functional Location-Based Reminder Applications

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ABSTRACT
Although they have potential, to date location-based information systems have not radically improved the way we interact with our surroundings. To study related issues, we developed a location-based reminder system, *PlaceMail*, and demonstrate its utility in supporting *everyday tasks* through a month-long field study. We identify current tools and practices people use to manage distributed tasks and note problems with current methods, including the common "to-do list". Our field study shows that PlaceMail supports useful location-based reminders and functional place-based lists. The study also sheds rich and surprising light on a new issue: when and where to deliver location-based information. The traditional 'geofence' radius around a place proves insufficient. Instead, effective delivery depends on people's movement patterns through an area and the geographic layout of the space. Our results both provide a compelling demonstration of the utility of location-based information and raise significant new challenges for location-based information distribution.

Author Keywords
Ubiquitous computing, lists, location-based reminder, PIM, cell phone, location-based information delivery.

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

INTRODUCTION
Does it never end? In today's busy workplace, knowledge workers complain "I'd be overwhelmed, but it's just one more thing to do" [8]. Yet when work ends, it doesn't. Evenings and weekends are packed with *everyday tasks*: taking children to school, buying the groceries, maintaining and fixing the house, attending social events and religious services, etc. While the home is the *base* for these tasks, many are performed elsewhere: a survey shows that Americans spend over two and a half hours each day at malls, stores, churches, auto-repair shops, health clubs, laundromats, salons, and other public places [11].

Our research focuses on understanding these everyday tasks – how people manage them today, what works and what doesn't – and the utility of *location-based reminder systems* (LBRs), for supporting them. LBRs are implemented on mobile devices equipped with position sensing technology (e.g., GPS). While previous research has investigated aspects of task management and LBR technology design, this earlier work leaves three major gaps that motivate our research.

From PIMs to everyday tasks. *Personal Information Management* (*PIM*) research explores the artifacts and processes people use to manage meetings, contacts, documents, events, etc. [13]. This research largely focuses on tasks performed in the workplace and information managed at the workstation [1, 2, 3, 4]. Researchers recently have recognized, however, that many tasks require *ubiquitous* personal information – untethered from the desktop – and have called for research in this area [3]. By our focus on personal *everyday tasks*, we meet this challenge. Our research has discovered a common pattern for doing everyday tasks: people pre-plan at a *base* (typically home or work), create *information resources* (frequently lists), and take these resources with them to *refer* to at the place where the task is performed (e.g., a grocery store).

Can my LBR manage your everyday tasks? LBR research began with proof of concept implementations [14]; a recent study explored how people create personal reminders for themselves [16]. We agree reminders are useful, but we ask: 'Is there anything more?' Can we enable new and more efficient practices? To date, there has been no explicit investigation of the process for completing tasks upon receipt of place-based reminders. We study practices people use to support errands and their satisfaction with them. A major finding of our research is that a key practice – creating and using lists – has some problems (e.g., lists are easily lost). We show other LBRs have not supported lists well, and PlaceMail does.

LBR: are we there yet? The whole idea of an LBR is that a reminder is delivered *for* a location. But what does that mean exactly? In practice, it has meant that a reminder is delivered when a user is *near* a location, defined as entering

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(or perhaps exiting) a "geofence" around the location. Our research shows that setting an effective delivery point is a complex process. When and where users want delivery depends on factors such as users' plans, motion patterns, (e.g., the route they usually take to the place) and the social geography of the area (e.g., if there are lots of distractions enroute).

We address these gaps through 3 research questions (RQs).

RQ1. What tools and practices do people use currently to perform personal everyday tasks, and what are their strengths and weaknesses?

RQ2. How well does PlaceMail support everyday tasks? Does it improve existing practices and enable new ones?

RQ3. What factors determine when and where a reminder for a location should be delivered?

The remainder of the paper is organized as follows. We first survey related work, illustrating how we build on or advance it. We then describe the PlaceMail system, highlighting distinctive features that appreciably affect usage. The heart of the paper describes the deployment of PlaceMail as a support tool for personal everyday tasks; we focus on how our results answer our three research questions. Finally, we discuss the implications of our results for future design and research.

RELATED WORK

Location-Based Systems. Previous researchers pioneered the LBR: early proof-of-concept designs include Cybre-Minder [6] and comMotion [14]. This work defined the basic idea – virtual reminders associated with physical locations, and the comMotion research culminated with a prototype built using wired hardware assemblies available at the time. The E-Graffiti [5] and GeoNotes [7] systems were technically similar, but targeted different usage situations such as social messaging or community announcements. And other reminder systems are location-based in a quite different sense: for example, Gate Reminder [10] is installed at the doorway of a house.

Recently, researchers have implemented location-based systems on cell phones and have studied their use in empirical field tests. For instance, DeDe supports location- and time-based social messages: a sender specifies a place or time when the addressee will receive a text message [9].

Similar to PlaceMail, Place-Its supports location-based reminders and runs on a cell phone [16]. Our efforts are closely related to the Place-Its research, so it is worth contrasting our projects. First, PlaceMail offers several new features not available on Place-Its. For example, PlaceMail has a web-based interface and a voice input function; these lead to distinct system usages. In addition, our empirical study differs from the Place-Its study [16]; the latter centers on opportunistic reminding. In contrast, we investigate existing practices for managing personal everyday tasks. This identifies unfulfilled needs that can be met by LBRs: we thus establish a baseline for comparing method and tool utility. We also examine the effectiveness of place-based delivery heuristics and present related design guidelines.

Personal Information Management (PIM). A number of studies characterize PIM research and illustrate its focus on novel systems for the workplace [1, 2, 3, 4]. Active topics in the HCI literature include: methods for managing meetings, contacts, documents, file systems, and outstanding tasks. Our focus is distinct – on *everyday* tasks. Processing these tasks differs – many are inherently distributed, with planning often done at a base (typically home or work) and execution done elsewhere (e.g., a child's daycare center). Therefore, concepts may transfer at some level – e.g., to-do lists are useful in both settings, however, the specifics can vary significantly. For example, to fulfill everyday tasks, people carry resources like to-do lists while mobile, and this can lead to a different set of issues.

Location-Based Message Delivery. Most location-based information systems, from comMotion to GeoNotes, DeDe to Place-Its, have used a simple, intuitively appealing method for deciding when to deliver a reminder for a location: deliver it when the user enters or exits some distance threshold (a geofence) around the location. Just one study that we know of has investigated effective delivery design. Paay and Kjeldskov [15] defined geographic regions around static attractions in a tourist area using architectural design principles. Like ours, this work defines tactics for effectively delivering location-based information. However, our work is distinct in that it targets dynamic situations. We inform delivery for users moving freely in the world – and their messages deliveries can be for anywhere - rather than in a set region with a fixed number of attractions.

Last, Tamminen et al. [18] reveal how people move through urban spaces in everyday living contexts. Their work describes general patterns, while we target how navigation affects ideal place-based information delivery.

PLACEMAIL

Now that we have characterized related research, we detail the PlaceMail application design. To begin, sending a PlaceMail is like sending email to yourself, but with a twist. Instead of receiving the message in an email browser, you receive it on a cell phone at a time and place of your choice. A short tune alerts you to incoming mail.

Implementation. We implemented PlaceMail on the Motorola i88s iDEN mobile phone, with Nextel wireless service. We chose a mobile phone rather than a PDA because the cell phone has been universally adopted for everyday use; the PDA remains a niche product. PlaceMail uses the phone's built-in assisted GPS (Global Positioning System) to sense location.

Interface Design. A major design goal was to make it easy for people to create reminder messages, a challenge given the tedious process of text entry on mobile phones.

Thus, while we implemented a phone interface for creating, viewing, and editing messages, we also provided two additional features. First, we designed a web interface with the same functionality as the phone interface (see Figure 1). The web interface emulates the look and feel of an email browser. Second, we implemented a voice message function: users can optionally record voice reminders on the phone in lieu of texting.

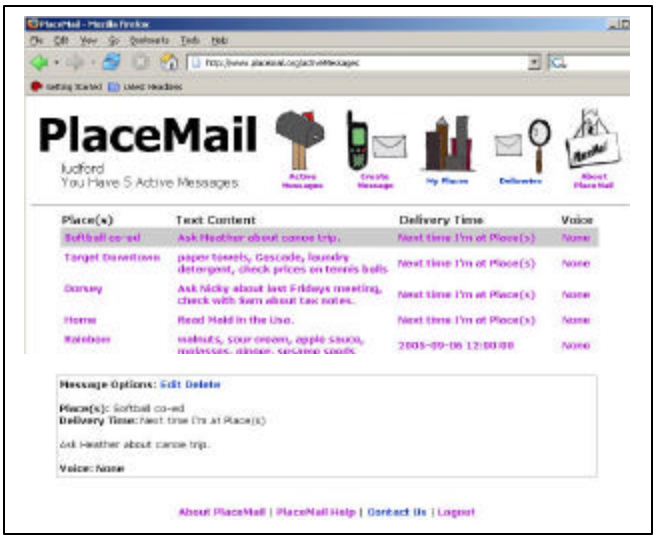

Figure 1. The PlaceMail web user interface design.

Specifying Message Delivery. Users can specify one or more delivery places for a message. For example, a user might associate a message "Check furnace filter prices" with several hardware stores (see Figure 2). The message is delivered when the user is near any of the stores.

Users can specify a delivery date and time instead of, or in addition to delivery place(s). When both place(s) and date/time are specified, PlaceMail "activates" the message at the given date/time. It then begins checking whether the user nears a specified place.

Place acquisition. As Figure 2 shows, users select message delivery points from a list of personally meaningful places. At the onset of the study, subjects provided us with places they commonly frequent. We used Google Maps (maps.google.com/) to compute the latitude and longitude of their places and entered this information in the PlaceMail database. We note that automated place acquisition is not a focus of this study, and that other researchers are investigating this issue [19]. We believe LBRs will need to exploit automated acquisition methods in order to proliferate in the future.

User Interactions. To create a PlaceMail message, the user follows a simple 3-step process. After logging into PlaceMail on either the web or cell phone, the user: (1) specifies where she wants to receive the message by checking delivery point(s) on her place list (see Figure 2), (2) enters the body of the message as text or an audio recording, and (3) optionally selects a delivery time for the message. After saving the message, the user can view, edit, or delete it via either the web or phone interface.

When a PlaceMail message arrives, the cell phone plays a short tune. Messages are delivered once, but the user can request redelivery at a future date and time upon receipt. If they choose this option, the system re-activates the message at the specified time, and redelivers it when the user subsequently nears a relevant place.

Figure 2: Specifying places for a message to be delivered

System Architecture. PlaceMail uses a client-server architecture. PlaceMail stores user data (places and messages) in a database on a server. This enables easy synchronization between the phone and web-based clients. The phone client retrieves a user's places and current messages at login over a wireless HTTP connection. During active use, messages are stored locally on the phone. New or edited messages are pushed to the phone and web client every 60 seconds. Most important, the phone client takes GPS readings at frequent intervals (every minute) and sends this information to the server, where computations determine whether any messages are relevant to the user's current location. If so, they are delivered.

Computing Location. We use a three-tiered procedure for computing location. First, we use the GPS reading whenever available. However, since GPS uses line of sight to satellites, it does not work if a user is indoors, in an "urban canyon", or the line of sight is otherwise obscured. The assisted GPS software on the i88s always knows the latitude-longitude of the serving cell tower; we use this to implement two fallback methods when GPS is unavailable.

In our primary fallback method, we employ the last GPS reading as a surrogate for the user's location. This works well, for example, if the GPS signal is lost when the user enters a building and she is currently situated there. We identified 2 instances, however, when this is unlikely to be the case: (1) the last GPS reading is very old (we chose > 12 hours), or (2) the last GPS reading is distant from the current serving cell tower (which we define as > 2 miles). If neither of these circumstances is true, then the last GPS reading serves as the user's location. Otherwise, we fallback using a second method: we employ the serving cell tower latitude/longitude as the location surrogate. This method is least accurate so we use it only when the other methods fail.

Delivering messages. In addition to location, the PlaceMail program acquires the user's estimated speed from the cell phone software. The application uses both of these factors to determine when to deliver a message. First, if the user is moving, PlaceMail delivers messages for places they can reach within 2 minutes, given their current speed. Or f the user is stationary, the system delivers messages for places within a half mile. As we discuss later, our results show that this simple, intuitive delivery procedure does not sufficiently ensure that messages are delivered when and where users want them.

EXPERIMENT: DESIGN AND METHODS

During the summer of 2005, we conducted a field study to investigate the utility of PlaceMail for supporting personal everyday tasks. We recruited subjects through community newspapers and mailing lists, and used an online survey to find participants who regularly perform *everyday tasks* such as grocery shopping, home repair, and child-related chores. 20 qualified subjects participated. Their backgrounds include advertising, marketing, chemical engineering, IT consulting, nursing, architecture, communications, stay-at-home parents, and small business owners. 12 of the subjects have children living at home. None of the subjects knew members of the research team prior to the experiment.

Subjects used PlaceMail for 4 weeks. To get started, we met each participant for a detailed face-to-face interview. The goal of the interview was to address RQ1. To this end, subjects brought at least one physical artifact that they use to manage everyday tasks. We discussed in detail how they employ the artifact, as well as other management methods and effectiveness of current practices. Subjects also learned how to use PlaceMail, and we assigned them an i88s phone. These sessions lasted 45-60 minutes. At the end of the study, we conducted in-depth interviews with each subject about their experiences with PlaceMail; these interviews helped us answer RQ2. The exit interviews lasted about an hour.

We told subjects to use PlaceMail just as they wanted: they could send any type of message to any place and use any system feature. We asked subjects, however, to send and receive at least 2 messages a week. We offered a modest incentive: two random subjects who participated at the minimum level received a $50 gift certificate. 90% of the subjects met the requirement. On average, subjects created 17 messages during the study. We analyzed usage logs and interview responses to answer RQ2.

We addressed RQ3 by sending subjects an online survey after they received a PlaceMail delivery. The survey was administered within 24 hours of message receipt and inquired about the message's utility and delivery conditions. To lessen the subjects' effort, we did not query them after every receipt. Instead, we randomly sent surveys for 22% of all message delivery events. We sent a total of 77 surveys and got 67 responses for an 85% response rate. We administered the surveys via email to elicit user comments; this proved effective as 62% included free-form observations that helped us answer RQ3.

RESULTS

Basic Usage. Subjects created 344 messages, an average of 17 per person (min: 4; max: 31; std: 7.42). 189 (55%) were created with the web interface, 79 (23%) with the phone voice interface, and 76 (22%) with the phone text interface. Text messages created from the web averaged 33 characters in length, those created from the phone averaged 13; the overall text message mean length is 28 characters.

51% of the time, the recipient wanted message delivery at a place or places, 33% at a place and date/time, and 16% at a specified date/time only. Of messages that specified a delivery place, 92% specified one place, 8% multiple places. The majority of messages – 61% - were for public places, including retail stores, parks, libraries and post offices. 18% were left at home, 5% at work, and 16% of messages had only a delivery date/time, not a place. This message/place distribution differs significantly from the recent Place-Its study [16], where subjects left 80% of messages at their home or workplace.

This difference could be due to different place acquisition methods. Place-Its subjects had to physically visit a place prior to leaving a message there. In the 2 week long Place-Its study, perhaps subjects did not visit many places other than home and work. In contrast, PlaceMail subjects could leave messages at any of their places starting on day 1 of the experiment. The PlaceMail usage pattern reflects the distribution of everyday tasks: recall that a previous study found that people spend over 2 ½ hours a day at places commonly associated with errands [11].

With this background, we now address the core of our results, which are organized around our three research questions. We begin with RQ1 and describe subjects' everyday task management practices prior to using PlaceMail. We follow by identifying opportunities for improving these practices, and then address RQ2, which addresses how subjects employ PlaceMail. To review, here are the first two RQs.

RQ 1. What tools and practices do people use currently to perform everyday tasks, and what are their strengths and weaknesses?

RQ2. How well does PlaceMail support everyday tasks? Does it improve existing practices and enable new ones?

Study subjects commonly employ a basic *record* and *refer* strategy for managing everyday tasks. 95% of subjects reported that they first *record* task-related information on a list, calendar, day planner, or other tool, and later *refer* to the information as needed. Typically, subjects record information at a base location such as home or work and refer to it at the place where they carry out the task. They occasionally update task information when mobile.

List Types and Strategies. The most common record and refer artifact is the *list*: 90% of the subjects regularly keep

both shopping and "to-do" lists, typically writing them on paper. Lists can be sequential. For example, three subjects put multiple places and related tasks on a single list. They run the errands during a single outing, usually ordering them to minimize transit time. The list serves as a point of reference: they check where they should go next, and may dynamically adjust their plan if they are running short on time.

According to subjects, lists constantly evolve. For example, 85% explained that they continuously maintain a grocery list: when they purchase an item, they cross it off the list. When they get home, they start a new list, carrying over unfulfilled items from the old one.

List Benefits and Drawbacks. Paper lists, often written on the ubiquitous Post-It, are lightweight and thus easily portable. As a result, they are often used for tasks like grocery shopping, which require leaving the "base". However, lists present problems at reference time. For example, subjects said that because lists are small, they are easy to lose (for instance, the note in Figure 3 was written on a 3" x 3" Post-It). Limited size also limits the number of items that can be recorded. As lists expand, people resort to crowding in new items however they can, typically writing later items smaller and between previous items. And as subjects cross out completed items, the list becomes messier; unfulfilled items may go unnoticed. When circumstances merit, subjects recopy partially completed lists onto new pieces of paper.

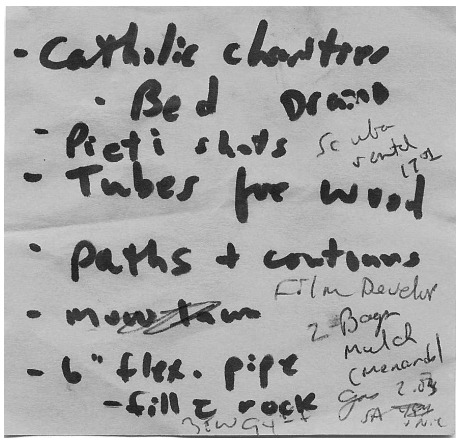

Figure 3: One subject's to-do list, which illustrates: (a) paper lists are typically small: a 3"x3" Post-It is easily lost; (b) lists evolve: some items are crossed out, different inks indicate intermittent updates; and (c) paper has limits as a list-making technology: items are not aligned, some words are very small, there's no room to add more items (although that didn't stop the subject from trying!). There's no way to reorder items.

Paper lists can only be in one place at a time, and subjects said this is frequently a problem. One characteristic participant said: *"it is difficult to anticipate when I will need my shopping list."* Shopping trips often are unplanned and opportunistic ("I'm out for lunch, so I'll drop by the pharmacy on the way back to work"). If she does not have her list, then she either has to stop for what might turn out to be an inefficient shopping expedition ("oops, I forgot to get cold medicine!") or else miss the opportunity and be forced to go out at a different time when the list is at hand.

Figure 3 depicts a study subject's list, and exemplifies several of the points we have made.

Improving the list. We observe that lists are commonplace, yet they have a number of weaknesses. As developers, we saw this as an opportunity: a well-designed tool could reduce problems such as lost or forgotten lists, messy, disorganized or unreadable lists, and the need to re-copy copy partially completed lists. While it seems natural that an LBRs *should* support list management, in practice this had not been the case: in the Place-Its LBR field study, subjects did not create lists [16]. We show next that our results differ.

Lists, Dos, and Get: PlaceMail Usage Analysis

After the PlaceMail study was complete, we assigned each of the subjects' 344 reminders messages to one of ten categories[1]. We began with the classification scheme used in the Place-Its study [16], but we extended it to fit our data. This was necessary because Place-Its users didn't create lists, but PlaceMail users did.

29% of all PlaceMail messages were lists, which we categorized into three types. First, *shopping lists* contain two or more items the subject wanted to get from a single place. Second, *to-do lists* record two or more tasks the subject wanted to perform at a single place. Third, *multi-place lists* contain tasks for more than one place.

Moreover, another 23% of messages were reminders to *get* a single item from a place, and 26% of messages were reminders to *do* a single task at a place. In effect, these are single-item shopping or to-do lists. Thus, 78% of all messages were reminders to get one or more items or do one or more tasks.

Table 1 summarizes and illustrates the most frequent message types. Five other categories accounted for the remaining 22% of messages; none of these categories accounted for more than 6% of messages.

Our results contrast markedly with those of Sohn et al. [16], (Place-Its), the only comparable study. As we mentioned earlier, Place-Its users didn't create lists at all, and *get* and *do* accounted for only 30% of messages. We think this difference is due largely to our web interface: over 86% of all lists were created with it (and of the remainder, 6% with the voice interface and 8% with the phone text entry interface). Place-Its provided only a cell phone text entry interface. This likely explains why Place-Its subjects didn't

[1] Two independent coders classified each message. The inter-rater reliability was 86% (91% for lists).

make lists: the input method was tedious for longer messages.

Message Type	Example	Proportion
Do	"Use 40% coupon"	26%
Get	"Buy raisin bran"	23%
Multi-place list	"Eat at Punch before stopping at B&N for Harry Potter"	8%
Shopping list	"Shampoo, body wash, dryer sheets, downy"	16%
To- do list	"Cash check, extra envelopes, submit XLE form"	5%

Table 1: List, Do, and Get messages in PlaceMail

TASK DETAILS

Next, in initial interviews, study subjects explained they commonly record task details on paper for later reference. For example, one participant showed us a notepad with this information on it:

7/11/05 check # 7658876098, New York, NY $138.00 → check court order to see if I need to reimburse.

(Actual values have been changed to preserve privacy). The subject explained that she needed to research child support issues and recorded background information about the task on paper. This type of cognitive offloading was common among study participants.

Task Details on Paper: Benefits and Drawbacks. According to study subjects, paper generally is a popular medium for recording everyday tasks for several reasons. It is cheap, universally available, fast, and easy to use. In addition, paper is lightweight and easily portable. However, task details written on paper suffer from the same drawback as paper lists: the reference is easily misplaced.

Task Details in PlaceMail. 37% of the messages subjects created during the PlaceMail study contain specific task details. For example, one subject left the message, "*pick up 21 ½ inch Weber grill grate*" for a hardware store. This behavior marks an advance: Place-Its users did not record task details [16]. We believe the PlaceMail web and voice interfaces again explain the difference. Subjects recorded 89% of task details with the web interface, 5% with the voice input interface, and 6% were texted directly on the cell phone.

DAY PLANNERS AND CALENDARS

Prior to using PlaceMail, five participants showed us how they employ (paper-based) day planners for everyday task management. First, they demonstrated how they frequently add place-based information and other artifacts to their planners. For example, one participant puts post-it notes containing "to do lists" in her planner. She attaches the note to the day when she wants to complete the list, and removes the post-it when all of the listed tasks are fulfilled. She explains it is easy to move the post-it to another day if the tasks aren't completed as planned. Frequently, the lists contain one or more place-based errands. Another subject stores long-term reference information in his planner. For instance, he recorded the size of his home's furnace filter and refers to the planner whenever he needs to buy a replacement.

Subjects who routinely use day planners reported carrying them everywhere, including to personal appointments, in their car, and into the grocery story for reference while shopping.

Day Planner Benefits and Drawbacks. Like other paper media, subjects find it easy to record information in their planners. And while lists are easily lost, subjects did not have this problem with their day planners. We conjecture this is largely because of their size. The day planner serves as a center for several types of information (calendars, lists, and long-term reference information), and users find benefit in this affordance.

According to study subjects, day planners have two main drawbacks: first, they are bulky and thus sometimes awkward to carry. Second, while it is easy to add information to a day planner, sometimes the user forgets to refer to it at the opportune time. We will revisit this notion in an upcoming section on opportunistic reminding.

Calendars. In the pre-study interview, 18 of the 20 subjects reported using a paper calendar at home to coordinate personal and family events. The calendar is kept in a stationary, prominent place in the home - this affords easy viewing and updates. The subjects do not typically bring their calendars on errands. One participant explained this is not necessary: if she unexpectedly needs the calendar while away, she follows up with a phone call or email after arriving home.

In addition, four subjects use the calendar feature on their PDA. While these subjects carried the PDA between home and work, they did not usually bring it on errands. This behavior is consistent with the paper calendar: subjects primarily update and refer to it at a base.

Calendar, PDA Benefits and Drawbacks. Participants said the paper home-based calendar is easy to update, difficult to lose, and is often in their line of sight so they are constantly reminded of upcoming events. Subjects did not report any major drawbacks with these calendars.

Subjects also find the PDA calendar beneficial. Those who use it avoid direct text entry by updating appointments on a desktop computer and synchronizing it with the PDA. It is interesting to note that many subjects understood the relationship between the PlaceMail web interface (where they created messages) and the cell phone client (where messages were delivered) as a similar form of synchronization. They observed that both methods provide the same affordance: they can avoid text entry on the mobile device if they choose.

Last, we asked subjects if they employ their PDA for everyday task management beyond calendaring. Most had tried doing so, but stopped for several reasons. First, they find text entry tedious, and also said PDAs are too bulky to

carry conveniently. This is part of the reason why the cell phone, not the PDA, has become the ubiquitous consumer mobile device. 75% of our subjects said that they would be unlikely to use PlaceMail if it ran on a PDA instead of a phone. One subject put it succinctly, noting that this was "because I carry my cell phone anyway".

OPPORTUNISTIC REMINDING

Finally, we inquired about methods subjects use for opportunistic reminding. Recall that an opportunistic reminder provides a "just-in-time" or "just-in-place" prompt, telling the user to take temporally or spatially relevant action. To this end, some subjects said they leave notes in strategic places, such as post-its on the front door reminding them to bring items as they leave. Many record phone messages or send email: for example, they leave a voice message at their home phone number and it reminds them to complete a task when they arrive.

Opportunistic Reminding: Benefits and Drawbacks. Subjects struggle to find effective opportunistic reminding methods. While strategic notes work well in the home or office, many everyday tasks happen at other places where notes cannot be viably positioned. And a phone or voice message cannot be sent to oneself at a public place such as the hardware store or community center.

In addition, subjects said that lists, day planners, and other paper task-management media can fail because they do not provide opportunistic reminding: a person can record information, carry the artifact when mobile, and still forget (a) to go to the place where they have to do the task, or (b) to refer to the relevant information at the proper place. On subject put it this way: "I hate getting home and realizing I need something from a place I just was."

These results are related to research by Taylor and Swan [17], who also found that people have problems with lists at reference time. Since lists can be organized in many ways (by place, time, importance, etc.), users do not always remember to refer to them at the right time.

After learning about the weaknesses in current opportunistic reminding practices, we saw an opportunity to improve the situation. We leverage the location-sensing affordances of the cell phone and provide location-based opportunistic reminders. Let's see how PlaceMail performs in this capacity.

PlaceMail for Opportunistic Reminding. To evaluate PlaceMail's location- and time-based reminding functionality, we surveyed subjects after they received PlaceMail deliveries and asked the following:

- *Were you already planning to go to the place when the message arrived?(Answer choices:* Yes, No)
- *Did the PlaceMail message remind you to complete a task? (Answer choices:* Yes, Somewhat, No)
- *Did you complete the task related to this message after receiving it? (Answer choices:* Yes, No)

We defined opportunistic reminding as an instance when the subject was not planning to go to the relevant place, i.e., they answered question 1 "No". When this was the case, they answered question 2 "Yes" 33% of the time, "Somewhat" 38% of the time, and "No" 29% of the time. In other words, 33% of reminders were clearly useful, and only 29% were not useful.

We also measured how often a PlaceMail delivery changed the subject's behavior and they spontaneously fulfilled a task. This was the case when subjects answered question 1 "No" and question 3 "Yes". This occurred 27% of the time. Note that the responses to question 2 (outlined in the previous paragraph) show that the remaining 73% of reminders weren't useless: subjects often indicated it was useful to receive a reminder even if they could not complete the task right away.

To exemplify how PlaceMail improved opportunistic reminding practices, two subjects told us that a PlaceMail delivery helped them remember to use coupons when they made a purchase. They kept coupons in their purse, but "out of sight is out of mind". Another subject mentioned that PlaceMail is especially useful on his way to and from work. At those times of the day, he is busy thinking about other things and doesn't remember tasks that would be convenient to do along the way.

More on Lists and Details

Until now, researchers have viewed opportunistic reminders as they key benefit of LBRs. Our results show this view is too narrow. Instead, a cell phone that makes lists and task details available at the opportune place delivers significant utility. One subject explained that she rarely needs a reminder to visit a place, but PlaceMail nevertheless serves as a useful assistant because it automatically produces her shopping list on arrival at a store. For her, this provides two benefits: first, the system reminds her that she *has* a list: she does not always prepare one. Second, while she could put the list on a PDA, she finds it inconvenient to access documents via the PDA's menu interface. PlaceMail provides an advantage because it puts the list at her fingertips.

Survey responses also confirm PlaceMail's value beyond opportunistic reminding. If the participant was *already* planning to go to a place and received PlaceMail, the reminder was not opportunistic. Yet 73% of the time they rated the delivery as either useful, or somewhat useful.

This completes our summary of results surrounding PlaceMail as a place-based task assistant. We now move on to our final research question, which addresses effective location-based information delivery.

RQ3. Relative to a place, what is the best location at which to deliver location-based information?

Data from our study shows that if location-based information is delivered at a spot the user says is right, then the person is more likely to (1) complete the related task,

and (2) to find the delivered information useful. In Figure 4, we depict data from PlaceMail surveys backing this claim. For a given message delivery, we asked subjects:

(a) Whether the message delivery was *too close, too far,* or *just the right distance* from the relevant place.

(b) Whether they had completed the task afterward

(c) Whether the message helped them remember to do the task.

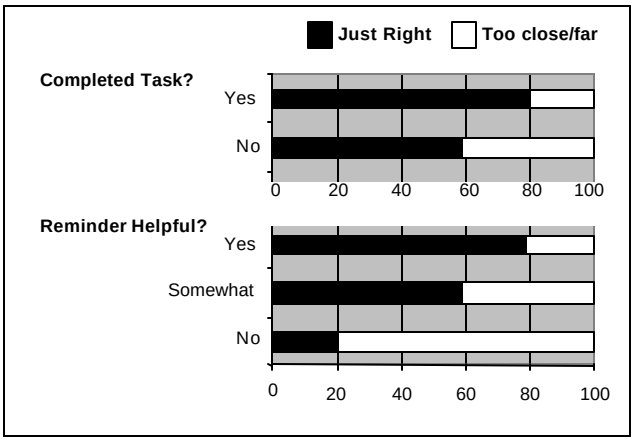

Figure 4. PlaceMail survey responses show subjects are more likely to complete tasks and find reminders helpful if they are delivered at the right location.

Delivering the message at just the right place is challenging. Recall that PlaceMail delivers messages when users are two minutes from a relevant place, unless the user's speed is zero, in which case it delivers messages for places within half a mile of their location. We thought that a model with these set parameters: speed and distance, would be sufficient to schedule useful message delivery. We expected to change the parameter values based on users' responses. The following subject comments illustrate that this model is too simple:

"If I am driving on the freeway, you need to tell me at least 2 exits before I get to the place that I have a message. I need time to maneuver through traffic to get to the exit."

"I received this message when I was too far away. I only want messages delivered when I am in the parking lot of the place."

It turns out that one speed does not fit all. Nor does one distance. After subjects received messages, we also asked (1) How far they were from the applicable place when they received PlaceMail, and (2) whether the message delivery was *too close, too far,* or *just the right distance* from the relevant place.

In Figure 5, we can see that these questions yielded varied perceptions: the ideal delivery distance fluctuates. We thus set out to understand the situational factors that affect people's preferred delivery points. We organize our findings around two broad factors: considering people's patterns of motion, and the geography of the area. We now explain the specifics.

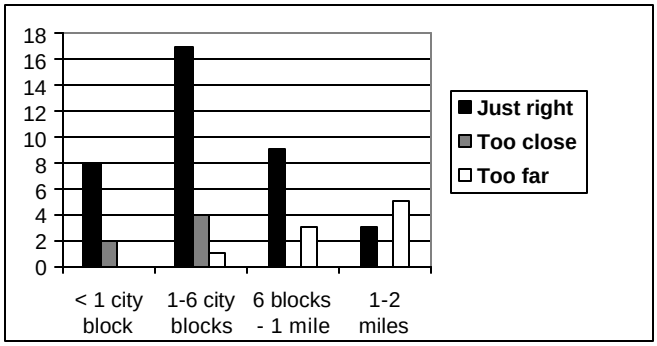

Figure 5. Survey responses show the ideal distance at which to deliver location-based information is unclear.

Patterns of Human Motion

We found that the time of day, duration of stay, amount of pre-planning, directional vector, normal travel routes, and perceived distance between points affect ideal location-based information delivery. We now provide delivery guidelines and exemplify their merit.

1. Deliver messages at appropriate times

One subject drives through the retail center in her town every morning on the way to work, at which point PlaceMail delivers her messages. She found it frustrating to receive deliveries then because she cannot stop while enroute to work. She pointed out that there is no way to specify that she only wants messages at certain times of day. Other location-based system users may have similar concerns. For example, a college student might only want to know about nearby friends when they are on their way home from class, and not the reverse. Asking people to schedule every message would be tedious, but user-selectable profiles ("college", "typical workday") or default time constraints ("only weekdays after 5pm") would be useful features.

2. Narrow the delivery radius for stationary users

In several cases, subjects were at home and received unwanted deliveries for nearby places. They preferred receiving these messages after leaving the house. We determined that when a person is spending a lengthy amount of time at a place, deliveries should be restricted to messages for the present location. This is because if the recipient is not leaving soon, they could receive the information and forget to act on it before they near the relevant place.

3. Deliver opportunistic reminders early, task details late

Earlier we juxtaposed quotes from two subjects: one who wanted message deliveries early so he could maneuver through traffic, and the other, who only wanted messages when she had reached the store's parking lot. The former subject was receiving an *opportunistic* reminder. He needed time to react because the delivery was unexpected. The other subject was *intending* to go to the place. She had no need for her grocery list before she arrived. We can imagine an analog of this situation in other location-based information systems. For example, a location-based

restaurant recommender might distinguish between two kinds of recommendations. In one case, the user is traversing an area, wondering if there are any good restaurants nearby. They may prefer to receive information before they reach recommended places. Alternatively, a person might be going to a specific restaurant wondering what to order. They may prefer receiving recommendations when they are at the restaurant and not before.

4. Deliver messages in ways that fit travel patterns

Several times, a subject received a message for the post office when she was within a reasonable distance. She explained that she only finds it convenient to go to the post office, however when she is on the road that passes right in front of it. To satisfy this requirement, the application will need to consider the user's path rather than just calculating the straight-line distance between points.

5. Deliver messages before the place, not after

Subjects sometimes received messages after they had passed the relevant place; they found this inconvenient. Because of this, delivery algorithms also need to factor in travel direction.

Geographic Layout Considerations

An area's built environment also affects the ideal delivery point. Specifically, the layout of the roads, public transportation systems, and density of attractions all influence delivery preferences.

6. Deliver messages using GIS information

Our results illustrate that a person's current speed does not necessarily predict their travel time to a target. For a driver traveling at 55 miles per hour on the freeway, the system will underestimate travel time if, for example, the path to the target includes an exit and side streets.

To assure greater accuracy in the future, we believe delivery algorithms will need to draw on Geographic Information System (GIS) datasets, which enumerate road locations and types. By accessing paths between points (rather than Euclidean distance), the system can more accurately calculate distance in terms of time. Currently, navigation systems such as MapQuest leverage GIS to perform similar calculations.

7. Deliver messages for mass transit riders

Information delivery systems will also have to account for other types of travel. For example, they ideally will discover when a person is traveling on a subway or bus and factor in scheduled stops and the transportation route.

8. Deliver messages considering the locale: dense urban areas feel smaller

In an urban area dense with retail outlets, a subject received a message for a place that was .51 miles away. Based on her speed, the algorithm had correctly calculated the delivery point. Given the crowded locale, however, she felt she was still distant from the place when she received the message. Given the traffic patterns and distractions between her present location and the delivery place she preferred a closer delivery. Ideally, location-based applications will identify and adjust to crowded areas and traffic patterns.

We conclude our delivery guidelines by noting that future research may uncover additional delivery principles, as well as reveal the prevalence of situations the require special delivery considerations.

DISCUSSION

In our study, we have taken a first step in extending LBRs to support everyday tasks. Further, to improve location-based information delivery we have illustrated how the ideal delivery location is influenced by people's patterns of moving through an area and the geographic layout of the space. We now discuss future implications of our work.

First, we can think of several ways to enhance LBRs to better address everyday tasks. Specifically, three areas require advanced support: *assorted list types*, plus *sequential* and *workflow* tasks.

Assorted list types. The study make us aware that lists come in different forms and that each of them requires special attention. First, to better address the continuous nature of lists, we suggest implementing them as "first-class objects". This means support for standard list-manipulation operations like adding and deleting items. With this change the user will be able to check individual items off a list, and the system will automatically preserve unchecked items for the next visit to the relevant place.

Next, we found that most subjects have shared lists, for example a grocery list that everybody in the household contributes to. To support these lists, the system will have to manage simultaneous updates and assure that multiple people do not buy (or otherwise fulfill) the same list item.

Sequential Tasks. We mentioned that study participants put multiple places and tasks on a single list and complete them during one outing. Subjects made similar lists with PlaceMail, but identified a necessary improvement. On the PlaceMail display, a person is only presented with tasks for their current location. On a trip with multiple errands, the user wants to see the entire list of planned visits and tasks so they can keep abreast of remaining tasks. In addition, they need to know in advance where their next stop is!

Workflow Tasks. We noticed two interesting recurring work patterns (which we call *workflows*), and PlaceMail is suited to serve both of them. First, a recurring event can necessitate a recurring *set* of reminders. One subject explained that during the experiment she used PlaceMail to record a series of messages for her monthly book club meeting. For example, "check if bookstore has book", "pick up book", "read book", "get treats for book club meeting", and "go to book club meeting". She will need the same set of reminders next month, so she would like the ability to store them as a set and revise them, adding appropriate dates and details each month as necessary.

We also noticed that subjects not only refer to task information when they are mobile, but they also gather it

and act on it later at their base. For example, one subject takes pictures of products she might buy with her cell phone camera and later does internet research on the products at home. In the future, PlaceMail could address this workflow by enhancing mobile information capture. Further the system could automatically display collected information on the desktop when the user arrives at the base and logs in.

Last, subjects asked that PlaceMail be integrated with other software. Almost all of the participants saw it as a natural add-on to office PIM software such as Microsoft Outlook. In addition, they sometimes wanted travel directions after receiving a reminder, so it could be effectively integrated with navigational software in mobile environments. We imagine these are just a few of the interesting ways in which LBRs can be extended to become better everyday task assistants.

Effective Location-Based Information Delivery. When it comes to effective location-based information delivery, we believe our study is just the beginning. Further research can uncover additional parameters that impact effective delivery. And while we suggest ways to resolve delivery issues, the proposed solutions are untested. In addition, our data shows that LBRs need to minimize interruptions: sometimes the user is already planning to go to a place and a reminder is unnecessary. In these cases, the system may still need to produce task instructions (for example, the user's shopping list) on arrival. We are not sure yet how an LBR can detect this situation. One potential solution is for the system to automatically infer the best delivery point based on message contents, but there are others. We look forward to resolving this and other challenges in the future.

We end by saying our research has not opened one door, but two. Our human-centered approach has both led us to discover that LBRs are suited to broadly support everyday tasks, and that good location-based information delivery depends on situational factors. Our results take us closer to a future where location-based information systems will improve the way people interact with their surroundings.

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