# Place-Its: A Study of Location-Based Reminders on Mobile Phones

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**Abstract.** Context-awareness can improve the usefulness of automated reminders. However, context-aware reminder applications have yet to be evaluated throughout a person's daily life. Mobile phones provide a potentially convenient and truly ubiquitous platform for the detection of personal context such as location, as well as the delivery of reminders. We designed Place-Its, a location-based reminder application that runs on mobile phones, to study people using location-aware reminders throughout their daily lives. We describe the design of Place-Its and a two-week exploratory user study. The study reveals that location-based reminders are useful, in large part because people use location in nuanced ways.

## 1 Introduction

Everyday we use special messages in order to help us remember future tasks. These messages, known as reminders, take many forms, such as post-it notes, emailing oneself, to-do lists, and electronic calendar alerts. For example, a student may send himself an email to remind himself to bring a book for class the next day.

Reminders can be more helpful when rich contextual information is used to present them at appropriate times in appropriate places. [7]. A grocery list reminder is more helpful while passing the supermarket en route home from work, rather than while at work or after getting home.

Several context-aware systems [8,10,19] have prototyped reminder applications [7,19], but the evaluation of applications built on these systems has only been conducted in limited areas. In a recent pilot study on location-based reminders, we found that the reminders that people wanted extend beyond life in the research lab into all aspects of their personal lives [18]. In particular, people often set reminders because the current context, both physical and social, prohibited completing the activity at the time. Therefore, our ability to understand the role of contextual reminders in a per-

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son's natural setting depends on a ubiquitous system being available consistently in a person's life.

A compelling platform for pervasively deploying context-aware reminders is mobile phones. Mobile phones with location-sensing capabilities are becoming state of the art, and several location-aware applications are available for use. The ubiquity of mobile phone networks enables pervasive location sensing, while the always-carried and always-on nature of phones mean that reminder creation and notification are permanently available to users. These factors allow a reminder system to be omnipresent in the everyday life of a user. In addition, reminder notifications on mobile phones do not require any extra hardware, and gives people a familiar device for in situ interaction.

Yet, the suitability for phone-based context-aware reminders is unclear. The sensing capabilities of phones are limited in the types of context and their accuracy of sensing. The limited input capabilities of mobile phones, combined with the tendency towards use while committed to another task, suggests a simplistic user interface that permits posting a reminder in a few key-presses. Can potentially inaccurate, one-dimensional reminders (*i.e.* using location) prove useful, and if so, how? Are the phone's capabilities in data entry, notification, and viewing adequate?

These technical and social limitations motivate the focus on location as a context cue. Recent advances in computing and location-sensing technologies are enabling high coverage location-sensing opportunities [15,16] to use in building location-aware applications. Most of these systems require some initial configuration, but can then provide pervasive location sensing throughout a person's daily life. Using one's location to trigger reminders is a potentially valuable piece of context that can improve the way people use reminders. Our aim is to find how location-based reminders are used when available throughout a person's day. Of course there are types of reminders in which location is not useful, but our focus is on those that could benefit from the additional location information. How and why does location figure into the relevance of a reminder for a person? How important is positional accuracy and timeliness to the usefulness of location-based reminders?

In the following sections we describe the design, implementation, and deployment of a location-based reminder application, named Place-Its, for mobile phones. This simple application, with the mobile phone as a platform, permitted the integration of location-based reminders into peoples' daily practice. We then report on a 10-person user study involving Place-Its over a two week period. The study participants found location-based reminders to be useful, despite relatively low location accuracy. In particular, participants found value in having the application always naturally on-hand for posting and receiving reminders, along with pervasive location sensing. Also, the participants used location-based reminders in numerous ways, including several in which the location served as a convenient proxy for other kinds of context. Finally, we conclude with a discussion of implications for future research.

## 2 Related Work

The idea of using location information in context-aware applications is not new. Much work has been done in the past in context-aware prototypes that have all shown location to be a useful element of context.

The Forget-me-not project was one of the pioneering efforts in the area of context-aware reminders. Forget-me-not employs a small PDA-like device that associates different items of interest with icons to help the person remember various tasks they need to attend to [17].

ComMotion is a more recent example of a context-aware system, supporting reminders that utilize location as contextual information [19]. Using GPS technology for location-sensing, people could set reminders around certain locations, with given time constraints. When the person was near that location and the timing constraints were satisfied, they would be alerted with an audio alert.

Cybreminder [7] took these ideas a step further, developing a reminder application based on the Context Toolkit [8] that focused on using a variety of context information, including location, to determine when best to trigger reminders. This project focused on abstracting hardware technology away from the developer. Thus, it was able to create a fully featured reminders application taking into account a variety of contextual information. This toolkit relies on the existence of special sensing hardware that limits its ability to be deployed ubiquitously.

Focusing on a different aspect of reminders, Stick-e notes [5] explored the post-it metaphor in the digital rather than physical world. Stick-e notes were placed at particular locations using GPS enabled PDAs, and could be made visible to others, thus emulating the affordances of physical notes in a digital environment.

Unlike the previously mentioned systems, ActiveCampus [10] examines mobile computing restricted to a university campus setting and provides a location-based reminders system using 802.11 radios to provide location sensing. A reminders feature is integrated into the system where people can set reminders to be triggered at predefined locations on campus, typically buildings.

The wearable computing research community has also had a number of projects exploring reminder notifications through extra hardware. Memoclip uses a small wearable computer that relies on location beacons distributed in the environment to trigger location-based reminders [4]. The reminder bracelet involves a bracelet worn on the wrist of the user that subtly alerts the wearer of upcoming events, as entered into their PDA calendar, using temporal information only [11]. The Sulaweski framework discusses a spatial reminder service that uses GPS and infrared to approximate a person's location and delivers reminders accordingly [20]. Memory glasses is another project that attempts to augment user memory by using subliminal cues [6]. The wearable remembrance agent used a heads up display to provide context-relevant information [21]. While some of these systems use implicit reminders, with some type of context or activity inferencing, they all find that subtle cues are effective. Like the systems mentioned above, these wearable solutions also focus on exploring new services that can be provided using location as context.

In the ethnographic space, Kaasinen performed a study examining people's needs for location-based services, using existing tools and methods [13]. People were given

GPS enabled devices and typical tasks to perform, with the focus being on their expectations for location-based services. The participants found the scenarios given to them to be unrealistic, as they felt the given situations did not reflect the real needs of people. They also expressed concerns about how location-aware systems might cause drastic changes in human interaction. Antifakos et al. examined the effects of imperfect memory aids when used to help recall. They found that displaying uncertainty helped to improve recall rates, especially in cases where uncertainty was high [3].

These pioneering efforts have generally not permitted evaluation in the context of people's normal lives. This is because they either used additional hardware, such as GPS receivers, that people typically do not carry around (taking both cost and inconvenience into account), or because they are restricted to a predefined area such as the campus of a university. GPS itself provides restricted location sensing, only operating in outdoor regions where line of sight with multiple satellites is available, whereas most people spend their days largely indoors, and even while outdoors GPS may not be available in areas such as "urban canyons". Studies conducted on university campuses typically use radio technology for location-sensing, requiring that beacons be placed in the environment, something that currently is not sufficiently available outside such settings [10]. Other location-sensing technologies, not listed here, could be used for a reminders application but possess similar restrictions, requiring special hardware [12]. Wearable computing solutions also require special hardware to provide many of the developed services. As a result of these constraints, it has been difficult to examine how location-based reminders could be used when integrated into someone's daily routine. The study here takes advantage of research done in client-side GSM-based location-sensing technology as well as the popularity and low cost of mobile phones to study location-based reminders, free of the aforementioned restrictions.

## 3 The Place-Its Application

Place-Its is designed around the post-it note usage metaphor, and named for its ability to "place" a reminder message at a physical location (i.e., a place). It usefully deviates from the metaphor in that notes can be posted to remote places. Although a person is home for the night, he can post a note at work to be retrieved the following morning upon arrival. To convey how Place-Its is used for location-based reminders, the following is a scenario based on Place-Its' actual usage by one of the participants from our study (screenshots next page).

> *Jill is currently busy at work, and remembers she needs to call her mom. She knows she will have free time when she gets home, so she conveniently creates a Place-It note (Figure 1a) that will trigger on arrival (Figure 1b) and remind her to call her mom (Figure 1c) at home (Figure 1d). Jill glances and sees that she has two other notes that are still posted (Figure 1e). After work Jill has dinner with her friends and arrives at home later that night. As she walks into the house, her phone vibrates and displays a message (Figure 1f), reminding her to call her mom. Immediately, she makes the call.*

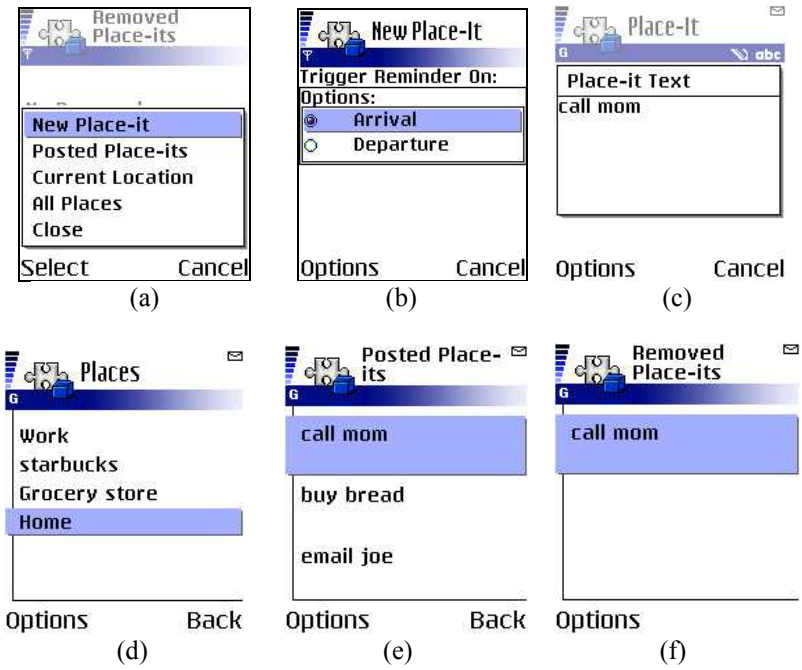



**Figure 1. (a)** Creating a new Place-It note; **(b)** Setting the note to be triggered upon arrival; **(c)** Typing the text of the note; **(d)** Posting the note to 'Home'; **(e)** Showing all posted Place-It notes; **(f)** The reminder is triggered when Jill arrives at the home and the note is removed.

The three components to a Place-It reminder note are the *trigger*, *text*, and *place*. The *trigger* identifies whether the reminder should be signaled upon arrival or departure of the associated *place*. The *text* is the message associated with the note. Reminders are created with a message, and then posted to a location on the person's list of places. People could use the phone's predictive text input for entering their reminder texts to ease the burden of typing on the phone's keypad.

A person can view all posted reminder notes at any time (Figure 1e) and can delete or edit any of the fields associated with the note. After a reminder note is posted on a place, when the trigger (arrival or departure) occurs, the note is automatically removed and put in the Removed Place-Its list. Once a note is removed, it can be edited, and reposted to the same or a different location.

We had three main design principles for the Place-Its application. First, it must be an always-on service, to ensure that reminder notifications are always possible and users can have confidence that they will get their requested reminders. A reminder system that is only available a small percentage of a person's day is ineffective if the message needs to be delivered outside the operational time frame. Second, the application must be easily deployable. Requiring people to carry extra pieces of hardware can hinder their integration of the reminder tool into their daily activities. The application is best deployed through a familiar artifact that people already use or carry on a daily basis. Last, for several reasons, we purposely omitted features to set time-based

reminders. This choice simplified the interface, omitting at least one step from the reminder creation process. It is also consistent with current reminder applications, which permit using just one kind of context (typically time). This was also a natural way to force all users to use location as their primary source of context when creating the reminder, even though they were not accustomed to it.

### 3.1 Mobile Phone Platform

Mobile phones offer a way to meet our first two design goals. Mobile phones are emerging as viable platforms for deploying personal ubiquitous computing applications. Multimedia, communications, and general computing capabilities are all converging to the mobile phone platform. Phones are also deployed and carried by over a billion people across the world, making them ideal for application deployment. Since people already carry mobile phones with them for communication purposes, they are unlikely to forget the device or have it hinder their normal activities. Mobile phones also present a convenience factor. Because people typically keep their phone handy for answering calls, they also can quickly create and receive a reminder note on their phone anywhere at anytime. Finally, the public use of a phone is, in the most part, socially acceptable. Given these advantages, our aim was to deploy an application designed for the phone platform, taking care to exploit these advantages where possible.

Place-Its is targeted at the Symbian Series 60 platform and was written using Java 2 Micro Edition (J2ME), with the Connected Limited Device Configuration (CLDC 1.0) and Mobile Information Device Profile (MIDP 2.0) APIs. The application contains a small portion of C++ code to access GSM cell tower information on the device. All development and deployment was done on the Nokia 6600 phone, chosen for its large screen and good developer support.

### 3.2 Location-Sensing

Achieving pervasive location sensing is essential for Place-Its to be useful. The Global Positioning System (GPS), with all its strengths and weaknesses, is the most widely used location technology today. However, it is not widely available on mobile phones, although it is beginning to emerge on certain models.

Another option would be to take advantage of the recent efforts by telephony providers to support accurate location sensing on mobile phones to meet E112/E911 requirements [1,2]. A by-product of this effort is the development of commercial pay-for-use location-based applications. It is possible to use a provider-based location mechanism for Place-Its, however these services are only emerging, without much support for independent developers to access location information directly. Per-use charging schemes would also cause high costs to be incurred by applications such as Place-Its, which need to continually monitor the user's location.

Looking to perform all location computations on the client device to avoid any charges by the provider, a better solution is Place Lab, a location system that relies on mapped radio beacons in the environment to provide location estimates [16]. Place

Lab for the mobile phone platform can use both GSM and Bluetooth radio technologies for location sensing. All computation is done on the client device, preserving people's location privacy. Previous studies have shown that Place Lab achieves approximately 100 meter accuracy and 100% coverage in urban areas. However, the initial requirement for cell tower location mappings is problematic since if a person moves outside of a mapped area, location capabilities are no longer available. Because it is costly to map every possible region where a person will go, we chose not use Place Lab. However, as the number of mapped regions grows, Place Lab would be a good solution for location-based applications like Place-Its.

We chose to use the location technique employed by Reno [22] for marking and detecting places, inspired by the ideas of Laasonen et al. [15], but simplified somewhat for our purposes. The key observation made by Laasonen et al. is that one can think of a place as a clique in a graph. This graph starts out as a set of nodes representing GSM cell towers. Edges are added to the graph between nodes as the phone observes a transition from one cell tower to another. A transition A-B means that a mobile phone was associated with cell A and now is associated with cell B. By using this strategy, the graph of nodes that a mobile phone associates with can be constructed.

When a mobile phone is stationary in one place, it does not stay always associated with the same cell tower; it "hops around" or, in the graph sense, traverses a set of edges on the graph. In a given location, the small set of nodes, a clique, that are traversed is typically quite stable for a mobile phone that is not moving. We watch for cyclic transitions such as visits to the sequence of nodes, A, B, C, A. The Reno location algorithm considers this the clique A, B, C. Reno's algorithm basically defines a place as the sequence of nodes visited in a cycle when that cycle has been repeated more than once. For example, if the sequence of nodes A, B, A C, B, A is observed, the algorithm considers the current place to be defined by the clique A, B. (C was not visited more than once.)

When trying to discriminate places, the algorithm simply takes the set of nodes seen recently (within some time window determined by hand tuning) and looks for cliques that overlap this recent list. For simplicity, the algorithm ranks the possible places (cliques) based on the amount of the clique that is "covered" by the recent nodes. This favors small cliques over large ones, but in practice causes few problems.


**Figure 2.** Once Place-Its is able to determine a unique location signature, the person can name the location by typing it in, or using a pre-defined "Cheat Sheet".

Once a place is determined, the person is able to label that place with a unique name (Figure 2). An advantage to this approach is that places can be identified wherever a person goes independent of any extra hardware or external data. A disadvantage is that a place must be previously visited and marked by the person before any reminder messages can be associated with that place.

## 4 User Study

In this section, we describe an exploratory user study of Place-Its performed with ten participants, over a two-week period in Winter 2005. We studied location-based reminders in the daily lives of people with different occupations, to analyze behavioral and usefulness factors for location-based reminders through a mobile phone interface. As an initial study, we emphasized naturalness over experimental controls, enabling us to observe genuine behaviors that could set directions for future research, as well as inform application design and future experiments. In this section we describe our experimental set-up, and in the subsequent two sections describe our results gathered from the study.

### 4.1 Participants

We recruited participants through mailing list postings and advertisements, seeking a group that used a variety of methods for creating reminders using other tools, had experience with mobile phones, and would manifest a variety of location-based reminder behaviors. The ten chosen participants consisted of students and working professionals, ages 18-45, three women and seven men (see Figure 3). Five of the ten participants were undergraduate or graduate students at different universities in the area. The other five were full-time working professionals. None of the participants had been exposed to using location technology for creating and delivering reminders before. Each of the participants had a GSM service provider, allowing them to use

| Participant | Age Range (Gender) | Occupation | Current Reminder Method |
|---|---|---|---|
| A | 18-21 (M) | Undergraduate | post-its, notepad |
| B | 18-21 (F) | Undergraduate | paper planner |
| C | 22-25 (M) | Graduate | email, notepad |
| D | 22-25 (F) | Graduate | None |
| E | 22-25 (M) | Graduate | electronic calendar, email |
| F | 25-35 (M) | Professional | PDA |
| G | 35-45 (M) | Professional | email, visible items |
| H | 22-25 (M) | Professional | post-its, electronic calendar, phone alarm |
| I | 25-35 (M) | Professional | electronic calendar, PDA |
| J | 22-25 (F) | Professional | post-its, email, electronic calendar, phone |

**Figure 3.** Demographic information about each participant and their current method of creating reminders. A-E are students and F-J are working professionals

our application and location detection algorithm, while maintaining their communication capabilities with minimal hassle.

The dominant reminder habits of the participants fell into four broad categories. Three used personal information management tools for their reminders (e.g., Microsoft Outlook, PDA), three used mainly email, and another three wrote their reminders down in a notebook or on post-it notes. The last participant did not use any of these methods, relying purely on memory.

### 4.2 Methodology

We conducted our study in three steps, a pre-study questionnaire, a two week long deployment, and post-study interview. Our pre-study consisted of a basic questionnaire regarding demographic information, mobile phone usage habits, and current methods of creating reminders. To help the participants personalize their Place-Its application, we asked each to provide, in advance, up to ten frequently visited places where they might want to set a reminder during the study. These pre-defined "Cheat Sheet" lists were put on the phone for the participants, enabling a participant to define a new place without having to type it in using the phone's keypad (Figure 2). The person was still required to visit that location and mark the place before they could label it.

We provided each participant with a Nokia 6600 to use during the study. However, they transferred their personal SIM card to the new phone for the duration of the study, thereby transferring their address book and allowing them to use the same phone number and phone network account. Since the phone was unfamiliar to some participants, we also conducted a basic phone tutorial. We explained our application, using the adapted post-it note usage metaphor. Each participant was told that before a reminder could be posted at a location, they had to have visited the location and named the place. Reminder notifications would be triggered by a phone beep and vibration, and would conform to the profiles of the phone. If the phone were in silent mode, a notification would not occur. Our participants were aware that we would be logging usage data on the device for analysis after the study completed. We asked the participants to incorporate the application into their daily lives and routines, using the application to set reminders as the need arose. After one week, the participants filled out a mid-study questionnaire by email regarding their experiences with Place-Its and the types of reminders they were posting.

Near the end of the two weeks the participants were sent a post-study questionnaire by email regarding their experiences with location-based reminders and the Place-Its application. The study concluded with each participant returning the Nokia 6600 and a 30 minute personal interview discussing their questionnaire responses.

## 5 Observations and Initial Classification

There were 89 reminders created overall, of which 67 (75%) reminders were arrival trigger reminders and 22 (25%) reminders were departure trigger reminders (See

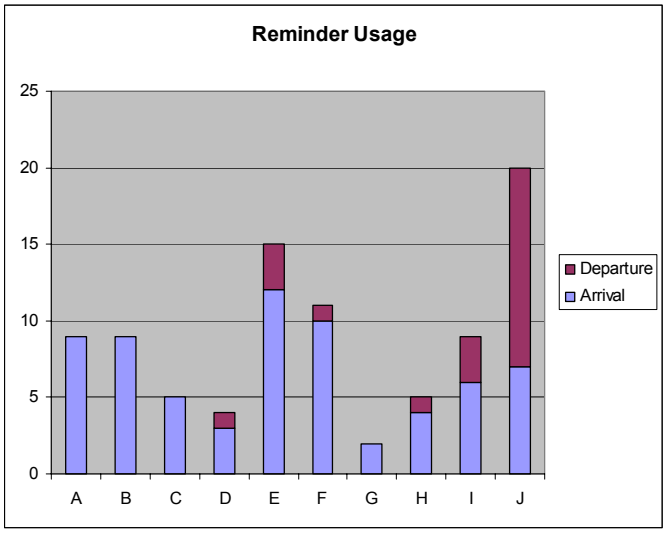



**Figure 4.** Reminder usage for each participant. 89 total reminders were created, 67 were arrival reminders and 22 were departure reminders. Participants A-E are students, and participants F-J are working professionals.

Figure 4). One of the main reasons we found for the smaller number of departure reminders is that many participants, after trying departure triggers for certain types of reminders (e.g., bring the book when you leave), found that the reminder came to their attention several kilometers away from where the reminder was needed. The problem is that a unique clique (see Section 3.2) could not be determined quickly enough as a person moved away from a location. Thus, departure reminders were generally not used and the tasks were accomplished with arrival reminders instead (e.g., pack book when you get home). This type of adaptive behavior is described further in Section 6.

Nineteen reminders (21%) were re-posted one or more times for a total of 63 re-postings. Reposting reminders occurred because either the reminder was triggered at the wrong location or the note was triggered at the right location, but could not be attended to at the time. Participant <I> reposted several reminders more than forty times to the same location to provide motivation to study every time he came home. Participant <E> occasionally visited a coffee shop close to the university campus on weekends. <E> posted a reminder on campus to be removed during the week when he went to campus, but it was falsely triggered during a visit to a nearby coffee shop. He therefore re-posted the reminder.

Although participants could post reminders wherever they had defined a place, 32 (36%) reminders were posted on a person's home and 39 (44%) reminders were posted on a person's workplace/campus. All of the participants reported in the post-study interviews that the majority of their desired reminders involved either the home or workplace/school. On one or two occasions, participants forgot to mark a place they had visited, preventing them from posting a reminder to that location when they

wished. For example, <I> wanted to set a reminder for a place he went to once a week. During the first week of the study he forgot to mark that place, thus was unable to set a reminder for the following week. If the study was conducted for longer period of time, these initial setup issues would have a lower effect. A technical solution would be for the application to automatically log time stamped cell tower observations. A person could define a place at a later time by correlating a visited location with a specific time, and then the application could retrospectively reconstruct the clique from the cell tower logs.

The time lapsed between the posting and removing of a reminder varied from minutes to days. We can discern no patterns, whether across the subjects, places, etc., suggesting that there is little time-based correlation between when a person remembers to post a reminder and when the person's location permits the activity to be performed.

### 5.1 Self-Reported Usage Data

We implemented an on-device multiple-choice questionnaire that would appear on screen after a reminder notification. The questionnaire consisted of 4 questions that could be answered quickly with a few key presses. Where are you in relation to where this reminder should be delivered? Was this reminder notification expected? Did you remember this reminder before the notification? Has receiving this reminder changed what you are about to do? The responses to these questions helped us gather feedback about the timeliness of reminder notifications and behavioral changes with regards to the reminder. We did not always offer a questionnaire after each reminder notification to avoid it becoming an annoyance. If the questionnaire screen was shown (about 50% of the time), the participant had a choice to ignore the questionnaire, or to proceed with answering the questions. If the participant did not respond to the questionnaire within a two minute time interval, the form would disappear from the screen. 49 (36%) questionnaires were acknowledged, and of those, 34 (69%) were answered.

Figure 5 shows a table of the 34 questions and the number of responses in each category. The dominant responses in Figure 5a show that most reminders notifica-

| | Correct Place | Not Correct Place |
|---|---|---|
| Expected | 25 | 0 |
| Unexpected | 5 | 4 |

(a)

| | Remembered | Not Remembered |
|---|---|---|
| Changed Behavior | 10 | 6 |
| Did Not Change Behavior | 14 | 4 |

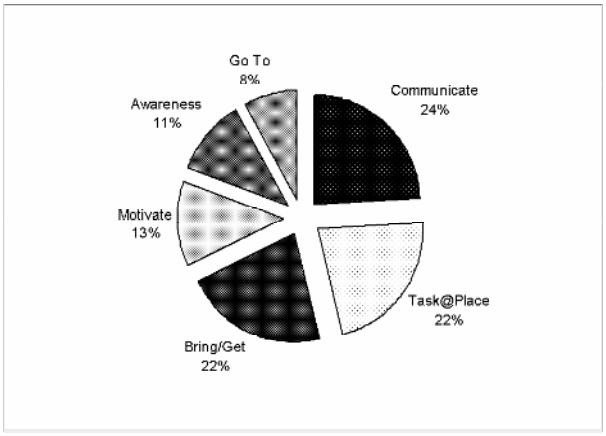
(b)

**Figure 5. (a)** Number of self reported responses about whether the reminder notification was expected and whether it was delivered at the correct place. **(b)** Self reported responses about if the reminder was remembered before the notification, and if the reminder changed what the participant was going to do.

tions were given at the correct place and the notification was anticipated. However, there were some reminders in which although the location was correct, it was delivered unexpectedly (e.g., on arrival instead of departure). Only four responses indicated that the reminder notification was not at the correct place, and hence unexpected. In Figure 5b, the horizontal dimension is whether the participant remembered the reminder before getting the notification. The vertical dimension represents if after being reminded, any behavioral changes occurred because of the reminder notification. The expected value of a reminder application is in reminding people about things that they have not otherwise remembered, and this is represented by 6 out of 10 non-remembered reminders causing a change in behavior. It is interesting though, that in 10 out of 24 cases where a reminder was for something that the user had already remembered, a change in behavior was nonetheless reported. This indicates that the Place-Its application was valuable as a motivation cue, beyond its memory-aid intent..

### 5.2 Classifying Place-It Note Usage

Psychology researchers have identified three general classes of prospective memory tasks: time-based, event-based, and activity-based [9,14]. Our application enables reminders in the event-based and activity-based classes. We classified the ways Place-It notes were used into 6 sub-categories, to analyze their function and use (See Figure 6). This is not meant to be a definitive classification of every reminder that a user might want to create, but simply provides an idea of how our application was




| Category | Communicate | Task@Place | Bring/Get | Motivate | Awareness | Go To |
|---|---|---|---|---|---|---|
| Description | email, call, talk to a person | a task that can only be done at a specific place | Bring/get an item from a place | motivate to do a task | being aware of an activity | go to a place |
| Example | "Talk to Ken" | "Start Baking!" | "Bring Book" | "Study Greek" | "Check the time" | "Go to grocery store" |

**Figure 6.** A classification of Place-It note usage into 6 categories.

used for the duration of the study. Some reminders could be interpreted to be in two or more categories; in these situations, participant feedback was used to disambiguate. The *goto* category maps directly to the activity-based class of reminders from psychology literature. The other categories are varying types of event-based reminders.

There are several noteworthy points in the frequency of the different types of reminders. The largest category is *communicate* reminders. These reminders involve emailing, calling, or talking to another person. This is somewhat surprising, since many forms of communication are not place-specific. An email can be sent from any location with Internet connectivity. Using mobile phones, calls can be made at any time as well. User feedback informed us that such reminders were typically created because, at the moment where the idea of communicating came to the user, they did not have enough time to actually perform this communication. This implies that location is being used as a reminder cue for other kinds of situational context (e.g., inactivity or cessation of an activity), which we expand on later.

Another surprise, given the inaccuracy of the location technology for departure reminders, was that *bring/get* reminders were tied for the second largest type. Participants considered this type of reminder important enough that they adapted to the limitations of the technology. Participant F created a reminder, "Bring metal case" to be triggered on arrival. Due to receiving the reminder, he would pack the metal case soon after he arrived home, thus not forgetting it when he left for work the next day.

Another unexpected significant type of Place-It usage was *motivate* reminders. These reminders did not necessarily have a high priority at the time of creation, but would sometimes increase with priority as time went on. They existed solely to motivate the person to perform a certain task such as "Study Greek" or "Go to the gym". Participant <I> would always re-post his motivation reminders after they were removed, considering them of low priority at the time of removal; however, as time for his Greek exam drew near, the motivation reminders became helpful in his time management.

## 6 Post-Study Responses and Discussion

### 6.1 Mobile Phones Offer Available, Convenient Reminder Creation and Delivery

Mobile phones provide a means of creating and delivering reminders that makes them attractive to users. We found that 8 of our 10 participants appreciated the consistent availability of location-based reminders through their mobile phone, and lessened their use of other reminder tools in favor of Place-Its.

**Quote 1 <participant J>:** *"Since I was out of town, I would think of things on the drive that I had to do when I got back and I'd put reminders on the phone. Even though I did remember what I had to do without the help of the reminder, it was a relief knowing I would've been reminded had I forgot."*

Participant <J> normally uses post-it notes or an electronic calendaring system to send herself reminders. However, in this situation, neither of these means were accessible to her, thus <J> found it useful to use Place-Its to create her reminder. In addition, having a reminder that would trigger after she came back to town was useful because Place-Its would interrupt her to display the reminder. With <J>'s current methods, it's possible had <J> forgotten the task, the reminder would have been overlooked. In our post-study interview <J> explained that she stopped using her current methods of reminders in favor of Place-Its due to its availability.

**Quote 2 <participant E>:** *"There are certain activities that my calendaring application is not particularly good at reminding me about. Especially to do something when I'm not near a computer. So getting reminders for these types of activities was a welcome behavior… [examples are] grocery shopping, and also when I'm leaving work I'm on my way out, done for the day, not liable to be checking email."*

The two methods that <E> uses for reminders are an electronic calendar for all reminders, and email messages for critical ones. Neither of these two methods allow <E> to trigger reminders when away from a computer, while Place-Its provided an always-available application. One of the successes was that on the way home, <E> was reminded to go grocery shopping, which would not have happened otherwise.

**Quote 3 <participant F>:** *"I didn't use my PDA much... it's much bulkier compared to just being able to use the phone"*

Although <F> normally uses his PDA for reminders, during the course of the two-week study, <F> found it more convenient to use the phone. <F> still carried his PDA with him by habit and used it for other functionality, but preferred Place-Its for reminders due to both its location capability and the fact that the phone was always within short range to use.

The convenience of mobile phones encouraged four participants, who may not have bothered to create a reminder in the past, to enter a Place-It for the sake of not forgetting it. As an interesting side note, some people found that entering a reminder helped reinforce their own memory to perform the task. One person said:

**Quote 4 <participant B>:** *"I would pull my phone out to silence it for class and [looking at it] would remember that a reminder would be coming."*

An important concern regarding the phone platform is the text input method. Many of the participants found text entry to take too much time even with predictive input support, so would resort to one or two word phrases. Those who wanted to input a grocery list found it easier to use Place-Its for the reminder to go to the grocery store, and have a separate paper list for the actual items. One possible solution to overcome these methods would be to use the voice and picture capabilities found on many phones today. This would enable quick voice memos, or snapshot pictures that would stimulate a person's memory about a reminder.

### 6.2 Location Provides an Indirect Cue for Other Context

The kinds of reminders posted and the way that they were posted strongly suggests that the location itself is not always important, but it is just a convenient proxy for context that is not as easily sensed or readily available.

**Quote 5 <participant E>:** *"I'm busy at work, so I don't want to make the call now, but I want to remember to call my sister when I get home"*

During the workday <E> was typically too busy to take the time to make a call to his sister. However, the phone call was of enough importance that he didn't want to forget about it. Since <E> knew that he would have more free time when he gets home, he set the reminder location for his home. The location itself was not important, but <E> knew that time will be more likely to be available when no longer at work. Motivational reminders are often similar in that the location has been chosen to catch the person in a particular frame of mind (or change a person's frame of mind). The location may afford that frame of mind, but in many reminders the "relevant" location was akin to "no longer at work or on the road.''

Certain locations imply access to tools that may be used by the person in completing a specific task. These tools may offer services not innately tied to the location, but in the person's mind, the task can be completed there.

**Quote 6 <participant F>:** *"I was in another building at work, when I thought to myself I should create a status report e-mail to send to my boss concerning my progress on a recent project. Even though I would be back in about an hour, I decided to post the Place-It on the phone. When I came back to my building, the beep went off right as I got back to my desk. Looking at the Place-It, the e-mail then became the next thing I did."*

<F> needed to write an email at a time when he did not have access to the tools he needed to compose one. Knowing that he has a computer back in his office and that he will be there shortly, he set a Place-It for his office. Sending the email is not something that is innately tied to his office; he could very well send one from any place where he has computing facilities for email access. However, he is able to take advantage of some knowledge about his schedule for the rest of the day to set a reminder for a location known to provide the services he desires in a timely manner.

Similarly, location can also imply the presence of other people, but without a reasonable guarantee:

**Quote 7 <participant C>:** *"I made a reminder for myself to ask a lab mate about a class, and I got the reminder just as he walked into the lab... I set the Place-it for the lab because I figured he would be there."*

<D> was really looking for his lab mate when he set this Place-It, but realized that his labmate would probably be in the lab at some time. Using this foresight to his advan-

tage, he set a Place-It there, knowing that it would draw his attention at a place where he would probably be able to find the person of interest. Although many context-aware systems have supported buddy alerts, this behavior demonstrates how setting reminders on locations can be used to alert the user when someone of interest is nearby, without the explicit ability to sense when buddies are nearby. Given the nature of certain relationships between people, it is often likely to find someone of interest at a particular location within a large but acceptable time range. By using this knowledge, one can use a location-based reminder to essentially create a person proximity reminder.

*Activity inference* is another context-aware feature that has long been desired and seems to be supported to some degree by location-based reminders, with some help from the user. A general statement of the challenge is to determine what the user's goal is in a long-running activity. Consider inferring the activity, *going to Kevin's house.* When asked to explain the thought process behind setting a Place-It on departure from work to "call Kevin," <J> responded:

**Quote 8 <participant J>:** *"I set the place-it for departure because I knew when I would go to the guys' place after I left work. Even if I didn't go there directly, I knew I would go there pretty soon."*

When she set this reminder, <J> had some notion of what her activity would be later in the day when she left work. She knew that her schedule entailed going to the guys' place eventually and very likely when she left work. This allowed her to use a departure reminder as a mechanism for aiding the system in adequately inferring her activity. In this case, leaving work meant it was probable that she was heading to Kevin's place.

As cited earlier, departure reminders often have high accuracy requirements. Indeed, they can even require predictive power—really activity inference: which of the several times that someone leaves their office during the day is the last time, so that they should be reminded to bring a book? Inaccuracy almost becomes a feature: who wants to be reminded all afternoon? Time-constrained reminders could have helped, but our users used arrival reminders as a proxy—you cannot leave a place until you have arrived, after all.

### 6.3 Location-Based Reminders Are Useful

In light of the above remarks, it is understandable that participant comments regarding location-based reminders were generally positive. Two participants (F, J) requested to be future research subjects because they found Place-Its to be helpful in their daily activities. They also asked if we could build a version of Place-Its for their current mobile phone to use on a regular basis. Six participants (A, B, C, D, E, H) considered location-based reminders to be useful to them, and their use of Place-Its to be enjoyable. The remaining two participants (G, I) did not find location-based reminders to be helpful, stating that their lives revolve around a set time schedule. They only desired time-based reminders or did not need any reminders at all.

During our post-study interview we asked each participant to describe any problems they experienced with Place-Its. These responses generally fell into two categories. Four participants had problems with the application being too easy to exit, or crashing. They were sometimes unaware of these events, and hence missed reminders. More significantly, the other six participants said the location algorithm used by Place-Its was sometimes not accurate enough for their reminders. The participants would get the reminder, but not necessarily at the right location. This degree of this perception lessened over time as the participants adapted their behaviors. One participant, not surprisingly, asked for time-constrained reminders.

Due to the way location-based reminders were used and the relative inaccuracy of location-sensing in Place-Its, we cannot claim location itself is essential context, even as we find it to be useful for triggering reminders. More than anything, its ready availability admits opportunistic use by those who can map their relevant (but unsensed) context to anticipated, coarse, location cues. Indeed, the two participants who work by a set time schedule are achieving similar results by mapping their relevant context to time cues and modifying their behavior. Providing location-triggered reminders expands the palate of context affordances that people can appropriate to guide their activities, accommodating a wider range of personal organizational styles.

## 7 Conclusions and Future Directions

The prevalence of mobile phones and the pervasiveness of their networks makes them a promising platform for personal ubiquitous computing. Our findings from a two-week deployment of Place-Its help validate that location-based reminders can be useful even with coarse location-sensing capabilities. Notably, location was widely used as a cue for other contextual information that can be hard for any system to detect. On the whole, it appears that the convenience and ubiquity of location-sensing provided by mobile phones outweighs some of their current weaknesses as a sensing platform. This bodes well for the use of mobiles phones as a personal ubiquitous computing platform.

Our study revealed unexpected uses of location-aware reminders. We found that Place-It notes were often used for creating motivational reminders to perform activities that would vary in priority over time. This is similar to using post-it notes in highly visible areas for motivation. The locations for motivational reminders were often set at frequently visited places, such as ‘home’. We also found that a majority of the uses for Place-Its involved communicating with people through a variety of media (*e.g.* email, phone). Communication is typically not tied to specific locations, implying that location is being used as a cue for other kinds of situational context.

As a first study, the results presented here are preliminary. Our results suggest a few application modifications that are worthy of further investigation. First, given the limited text entry mechanisms available on mobile phones, a way of associating audio messages or pictures with reminders could offer greater convenience, encouraging unique and more opportunistic use. Second, with an understanding now of how location affords certain classes of reminders, it would be interesting to investigate how adding time-constrained notifications changes user behavior. Third, research

into more accurate and faster location sensing on mobile phones should reduce the need for users to adapt their reminders to the capabilities of the application.

Finally, to both account for the effects of inaccurate location sensing and naturally support the use of recurring reminders, we propose a change to the user interface. Rather than the application automatically removing a Place-It when it is detected and presenting it as an explicit reminder notification, the application would continuously display a list of nearby Place-Its as to-do items, sorted by proximity to the current location. The user would then explicitly pull down a Place-It when it is no longer relevant, rather than repost it if it is still relevant. Alerts could still be provided when location certainty is high.

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