

# The design and evaluation of a mobile location-aware handheld event planner

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**Abstract.** The problem of designing and evaluating mobile computing applications is of growing concern in the HCI community, due in part to the difficulty of applying traditional design and evaluation methods to increasingly informal and unstructured usage contexts. We describe the design and evaluation of an integrated location-aware event and meeting planner built to work in a PDA form factor. We discuss the limitations and possibilities of location technology on mobile devices and how it can be used to create useful, usable, and elegant applications. We outline major design decisions, the results of qualitative formative evaluation performed with a small number of participants, and the second iteration of the design. Finally, we offer a number of general considerations on the design process and on specific issues related to mobile handheld applications, including reference metrics for design assessment, user training and cross-over effects from desktop systems.

## 1 Introduction

The rise of a cell-phone culture [7] [15] has substantially changed the way people plan and manage their daily activities and social interactions. People use a range of different tools and resources to organize events and meetings, to notify, manage, and track attendees and to send last minute changes to the time, place and participants.

Cell phones, wireless email, and even wireless connectivity to calendars have progressed greatly in the past ten years, though their full capabilities are still hindered by a lack of integration and cumbersome application environments. Planning events and keeping track of others remains a cumbersome and inefficient activity and a source of anxiety [4]. As mobile devices become location-aware [6] [2] [18], the ability to track and monitor users could greatly help people at keeping a hold of this increasingly frenetic lifestyle.

The project described here investigates how individuals deal with event planning and management and the related communication tasks. Using questionnaires, interviews, and discussions with potential users, we assessed the current state of mobile device acceptance and satisfaction and attempted to catalog the personal and contextually dependent ways in which people currently plan their meetings and informal events. The development and evaluation of a prototype thought us a number of interesting lessons, which we report at the end of the paper.

## 1.1 Related location-aware mobile applications

Location-aware applications have been one of the drivers of third-generation (3G) mobile operators' marketing efforts in the past few years [18]. To date very few such applications have actually been implemented due to a host of technical problems related to interoperability and precision.

One of the few available applications to offer more than customized web portals based on a city-level granularity is the AT&T Wireless "Find Friends" service [2], a location-based relationship management service running on mobile phones. After signing up and building a buddy list, similarly to current instant messaging systems, it is possible to locate parties with the same service in any area covered by AT&T. After locating a friend, the user can invite him/her to some meeting point chosen from businesses in the AT&T Yellow Pages.

The system is based on iMode<sup>1</sup>, which leads to poor performance in crowded areas, or areas with bad connectivity. The spatial precision of the system is linked to the antenna network structure; in densely populated areas, a precision of less than a kilometer is achievable, while in rural areas this figure can exceed 10 kilometers, making the localization very imprecise, and thus not very useful. This service does not fully take advantage of localization in the planning and execution of social gatherings. There is no way, for example, to sort the phone book based on proximity, or to include location information in SMS messages. Key drawbacks are the inability to invite more than one other party to a meeting and the disconnect between the "Find Friends" application, which runs in a browser, and the rest of the phone functions.

Another system of note is the HandiMessenger system [8], developed for commercial purposes but never marketed. The system adds rich meta-data to voice, email, and text messages, so that the receiver of a message can see the location (including presence) and calendar information of the sender. With this information, a user can decide on an appropriate means of getting back to someone.

Finally, the Personal Navigation Tool [3] centers around way-finding, with both map-based and text-based directions to specific locations. The system does not directly assist in the planning or execution of meetings or in communication, though its design and user preferences relate to our integrated design.

## 2 Analysis and Design

When people want to meet, whether for formal or informal purposes, the strategies they use to accomplish this goal can be time-consuming and cumbersome. The organizer(s) must get in touch with all the participants in order to notify them of the gathering and logistics. Unforeseen situations, such as changes to the venue or time, require updating participants. Based on a variety of considerations, including personal preference and availability, organizers juggle the tasks of managing the logistics of the gathering, updating participants, and keeping track of people, all in the pursuit of a successful gathering.

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<sup>1</sup> iMode is the trademark of an implementation of a subset of HTML and related browser, which runs on 2.5G and 3G cell phones, initially developed by NTT DoCoMo. [10]

We surveyed and interviewed individuals in our target demographic, 19- to 35-year old females and males, chosen according to market penetration, acceptance and spending forecasts [18]. We sought to understand the tasks users currently perform when forming meetings and gatherings, and the strategies and technologies they employ to accomplish these tasks, to identify problems and concerns that a new mobile location-aware system should address.

Respondents shared the feeling that the current crop of mobile tools is poorly matched to their tasks of meeting and “keeping up with” friends and acquaintances. Respondents recounted tales of woe when plans for the evening changed and notifying all participants took considerable time and effort on the part of the organizer, calling key attendees and asking them to call others. Messages, both text and voice, are constantly traded among friends in order to facilitate both working and friendly get-togethers. In particular, younger interviewees were prone to spending “the whole night” on their cell phones trying to contact each other, verify locations and plans, get directions, and make plans based on happenstance.

Interviewees expressed strong interest in how location-based technology might assist them in these tasks. Many of them were enthusiastic at the idea of offloading cumbersome and repetitive tasks to their technology artifacts, freeing them to worry about more important things. Colbert’s diary study [3] uncovered analogous frustrations among a similar demographic, noting that current mobile tools lose some of their effectiveness as participants are en route.

Further analysis showed that planning tasks vary in nature and detail depending on the formal or informal nature of the event. *Formal events* (e.g. for business purposes) are generally planned in advance. The organizer and other participants are motivated to ensure that the event runs according to plan and modifications are kept to a minimum. *Informal events* are often social in nature and do not require firm commitments ahead of time. Plans are not constrained, and individuals frequently modify logistics based on a number of social and environmental factors. Events with differing levels of formality require different tasks and therefore different support.



**Fig. 1.** A test participant using the system

Users were most interested in the systems that supported informal, rather than formal, gatherings. Moreover, they liked the idea of integrating an application into existing hardware to reduce the number of carry-on devices, but also liked the interactivity and map-based visualizations provided by the unique hardware with more screen-real estate. Finally, many of our respondents indicated that privacy would be a primary concern for them when using location-aware technologies.

Preliminary designs covered the entire range of computing devices from wearable items like an “intelligent keychain” (which alerts the user to the proximity of significant individuals while remaining unobtrusive<sup>2</sup>) to a fully integrated meeting planner, recorder and conference phone large enough to fill a briefcase. These “creative designs” allowed us to show to potential users (in a somewhat exaggerated way), and gather feedback on, the concepts which were then later incorporated in the prototype.

The final prototype is based on a PDA/phone combination,<sup>3</sup> which does not require users to carry an extra device and has a larger screen than a smartphone<sup>4</sup>, to support map-based visualizations. The device is assumed to integrate location technology such as GPS. The prototype is built with Microsoft Embedded Visual Basic for Pocket PC and runs on a Compaq iPaq. The design aims at supporting users in their goals of getting in touch with and keeping up with friends. Task analysis led to the identification of three main conceptual entities. *People* (and groups) hold information about contacts, including their telephone number. *Events* hold all the information related to an event: time, date, location, and invited participants. *Locations* are semantic markers associated with specific geographic positions.

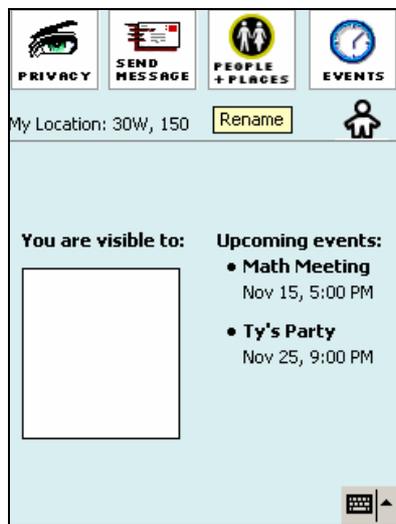


Fig. 2. Home screen



Fig. 3. People and place screen

<sup>2</sup> This design is similar to the Lovegetty device. See: [www.lovegetty.com](http://www.lovegetty.com).

<sup>3</sup> Like the Mindspring Treo, Audiovox Thera and the T-Mobile PocketPC Phone Edition.

<sup>4</sup> Such as the Panasonic GD87 or the Nokia 7650.

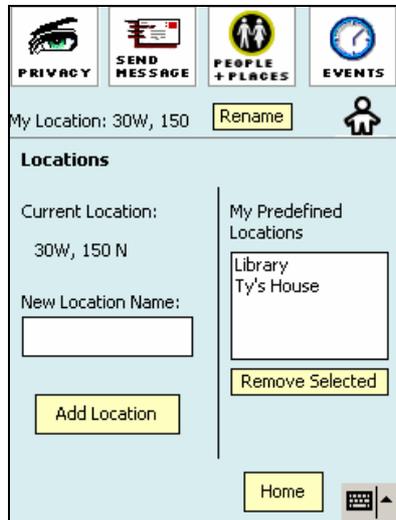


Fig. 4. Locations screen

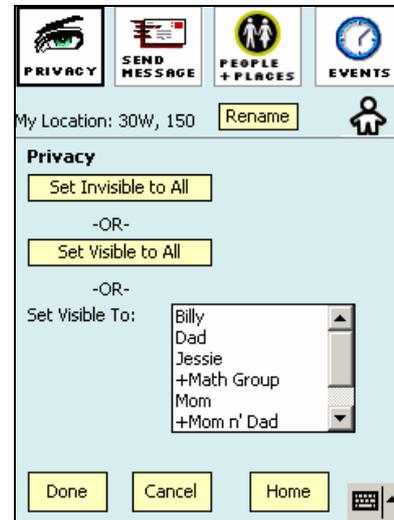


Fig. 5. Privacy screen

When a user starts up the application, she is shown the Home screen (Fig. 2), which reminds her of the people on her buddy list who can currently view her location. The man icon in the top bar fills up as she selects to be visible to more buddies. The screen also provides a summary of the most immediate upcoming events; more information about these events, or any of the others she has planned, is on the Events screen, which includes details including time, place, and people invited.

The People and Places screen (Fig. 3) supports the user in locating friends and event participants. She may wish to find out where the other participants are located in order to organize an impromptu gathering or to determine whether they are likely to be late at a planned meeting. The map displays her current location in relation to the locations of the people and groups on her buddy list. If she desires to monitor the progress of participants in getting to the meeting spot, she may select an event from her list in order to view all the participants' locations in the map display. Detailed directions for getting to a friend's location are available, as well as information about the estimated time required to get there and the distance that must be traveled.

A user may wish to add meaningful labels that correspond to certain GPS coordinates (e.g. turning "84.416 W, 33.75 N" into "Movie Theater"). These semantic markers can be set from the Locations screen (Fig. 4), which is accessed by clicking the "Rename" button. This label (rather than the coordinates) will be displayed thereafter as her current location whenever she is in that spot, and can also be used for scheduling future events and in writing messages.

The application allows users to organize meetings using two different methods. The more formal way is to schedule an event, which is accomplished through the Events screen (not shown). When creating a new event, the user can specify details including the time, place, and people invited and then save the event to her list and send notification to the participants. For spontaneous gatherings, she may instead rely

on text messaging, by sending messages to one or more of the people on her buddy list, and automatically include her location, to help her friends locate her quickly (e.g. if she is at the coffee shop and wants them to meet her there in five minutes.)

An even simpler way for a user to assist friends in locating her is to allow them to monitor her location. This may be useful, for example, if she is running late to a meeting and wants other attendees to monitor her travel progress, reducing the need for constant calling back and forth to communicate her progress. Through the Privacy screen (Fig. 5), the user can view and make changes to her current visibility status, by allowing or disallowing select people and groups on the buddy list to view her location. To promote simple and effective actions, a single click allows or disallows everyone on the buddy to see her location.

### **3 Evaluation**

The evaluation goal was to test the application's usefulness, appreciation, learnability and performance measures (described in detail below). Formative evaluation provided information about the prototype's qualities and shortcomings, yielding a new design and some key guidelines for the development of location-aware mobile devices.

The application was developed with enough functionality to allow for robust use during testing in an outdoors environment; the positional data for the user and the other parties (maps, locations, etc.) was hard coded in the prototype based on the location of the test. This setup was more than adequate for the purposes of our "semi-stationary" evaluation. However, in the case of evaluations involving large movements, testing would need true or Wizard-of-Oz location information.

We sought to collect qualitative data based on observation of participants' interactions with the system and post-test interviewing. In order to understand participants' mental models we adopted a talk-aloud protocol with three of the nine participants. We recorded a small number of quantitative measures, including time required to complete tasks on the remaining six tests and a satisfaction questionnaire. Because of the small number of participants, these quantitative measures are not statistically significant, but provide valuable information on the design and on timings related to interface components (e.g. the soft keyboard) and the application itself.

The average age of the nine participants was 26 (maximum 30, minimum 19, 5 females and 4 males). The average reported time for owning a cell phone was 3.9 years. All participants but one declared themselves experienced with PDAs, SMS, Instant Messaging (IM) and with stylus-based input methods. Most participants did not own a PDA and had no familiarity with GPS.

#### **3.1 Evaluation Design**

The evaluation consisted of a pre-test questionnaire to gather demographic data (including experience with mobile devices), a scenario-based evaluation, and post-test questionnaire and interview. We sought to evaluate the activities that potential users identified as important but time consuming or complicated:

- deciding on a meeting (event planning),

- inviting attendees to the event or meeting,
- making changes to the event,
- reaching the destination, and
- supporting the actual meeting (monitoring arriving participants, etc.).

We developed a set of 15 tasks covering the listed key activities and revolving around two scenarios: a typical afternoon in the life of a busy college student or young professional and his or her evening activities. Tasks included: “Locate an individual and send her a message”, “View event details and attendee locations”, “Make yourself invisible to all other users” and “Add a group to the buddy list”. In general, each of the 15 tasks required one minute or less to complete.

One researcher carefully observed participants in order to gain understanding of their interactions with the application, including comments, errors, recovery techniques and strategies for accomplishing the tasks.

Another researcher collected task timing data<sup>5</sup>, which we compared to pre-defined benchmarks, on six of the nine participants. Though this information is not statistically significant and is not presented here, it provided a lower bound for evaluating further design iterations. Also, users did not have canonical methods (or, in some cases, even similar methods) to accomplish the tasks of inviting and monitoring attendees, and changing venues and meeting times.

Considering the lack of benchmarks or models for assessing timings for this kind of tasks in the HCI literature, we resorted to comparing the data gathered from users with reasonable guesses at how long tasks should take, based on the same tasks accomplished using traditional means. Participants were not instructed on the specifics of the system before interacting with it, apart from a short demonstration of the soft keyboard, and were not shown how to perform the tasks beforehand; instead, they learned by trial and error to use the various features of the device. We took a cue from the current crop of mobile personal communication devices whose interfaces and system functions are all learned via use, not manuals.

All testing was performed in various environments on a university campus. Because we intend the system to support mobile and informal situations, we sought ecological validity for our evaluation, over concerns such as environmental consistency. We also attempted to simulate the integrated nature of our system inside of other personal communication devices. Users were interrupted by SMS and meeting requests while attempting to complete tasks as well as by environmental factors such as rain, friends, and traffic noise. Applications for mobile devices must be usable on-the-fly in real situations if we want them to integrate into users’ lives [11].

After participants interacted with the system, they were asked to fill out a questionnaire and to answer to an interview. In the questionnaire, participants rated the system (on a Likert scale) regarding usefulness, learnability, and ease of use. We also requested that participants rate their overall impressions of the system and asked whether they would use and/or purchase the application. The interview included a set of open-ended questions aimed at probing into participants’ mental understandings of the system, impressions about its usefulness and usability, and suggestions for improvement.

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<sup>5</sup> The timer was paused during interruptions of various kinds (greeting a friend, receiving a phone call, etc.).

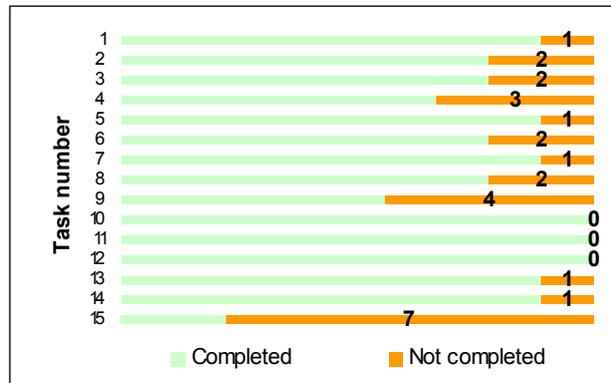


Fig. 6. Completed tasks. The numbers show how many participants did not complete the task.

### 3.2 Evaluation Results

Generally, participants were successful in completing the tasks, especially later tasks, which may indicate that the system is in fact learnable in a relatively short time by users with no prior training (see Fig. 6). The only tasks that were consistently difficult for multiple users (including tasks 9 and 15) were those involving the “Rename location” button (see Fig. 1 through 4); these difficulties are discussed below.

The average time required to perform each task (for tasks that were completed successfully) was computed over the six participants of the timed tests and roughly corresponds to the hypothesized completion time. The exceptions fall into a few broad categories:

- performance was better on later tasks than on earlier tasks. It is difficult to derive precise data about the learning curve; however, after the fifth task, performance improved noticeably and users accomplished most tasks in consistently low times.
- Some participants performed tasks by utilizing unforeseen strategies, which met the success criteria, although requiring more time.
- Most participants had trouble locating the screen where location information could be added and edited – those who completed the tasks succeeded by activating the proper screen accidentally or gave up after stumbling for a while.

One of the reasons for the third point is to be sought in the appearance of the “Rename locations” button, which participants did not recognize as such, despite its prominent location on the top-center section of the screen next to the location label: PocketPC buttons are flat, as opposed to the usual look of desktop UI buttons.

In fact, interference between training on desktop computers and the use of handhelds was observed during the entire evaluation process. This is not surprising; however, more interesting is the way such interference happens and what the consequences are. In general, participants experienced difficulties due to unfamiliarity with the interaction syntax of the PDA: they used the UI elements like the analogous elements on desktop UIs. As a result, users had problems in identifying active elements, and missed completely parts of the interface.

**Table 1.** Main qualitative findings

Qualitative result	Participant comments
Did not like / understand privacy icon	Participants noticed the privacy icon but thought that it indicated proximity to someone. Others thought it was not useful, because it did not indicate <i>who</i> was watching.
Problems of understanding maps	Participants had problems in assessing distances in maps. Others did not understand the icons on the maps. Others still preferred labels on the map.
Ergonomic factors	Keyboard interaction is uncomfortable. Integrate the application with other functions (e.g. phone).
“Rename” locations is confusing	Participants did not understand the way the application manages locations.
Lack of undo or confirmations	Participants wished a confirmation before committing irrevocable actions (e.g. erasing people from contact list).

We observed a negative correlation between task completion time and participant’s experience with stylus and PDAs and with IM and SMS writing: longer experience corresponded to lower times. The timing breakdown confirms that most of the task time was used in typing on the soft keyboard. Prior experience with the stylus reduced task time, but most participants found typing difficult and frustrating. Indeed, keys are tiny and close together, slowing down typing pace and increasing error rate: *the soft keyboard is not suited for on-the-move use of the PDA.*

By evaluating the prototype with participants without prior experience with the application, we gained information about how users can learn to use the application on-the-fly, and our evaluation suggests that users quickly gain familiarity with most features. However, it is unclear how a more experienced user would interact with the device. *These results suggest to separate evaluation of performance from that of learnability*, with the purpose of determining the time and effort required to learn the application and how this affects the success and satisfaction of their interactions.

Observation, questionnaires and interviews provided invaluable feedback about general design and specifics of the interface. The most interesting results of the qualitative analysis are synthesized in Table 1. Participants had problems both in understanding the iconographic meaning and the function of the privacy icon. Also, participants did not understand the significance of the asterisks in the buddy lists that indicate who can see the user’s current location. This led to a complete redesign of this part of the interface (see below), in order to make the icon more informative, and by binding it to the specific function of privacy management when touched.

Maps represented a challenge for participants; the amount of information which the display can convey is very limited, and sophisticated visualizations need to be implemented to make the most of the technology. Assessing distances on a small screen map is hard, and even a scale is insufficient for providing adequate information. Instead, explicit indication of distances between places of interest would provide the users with the information they need to take decisions. Participants also asked for legends to be included in maps, a design option which was initially discarded on the grounds that it would create too much clutter – but was added to the redesigned maps.

**Table 2.** Results from post-questionnaire. All responses are based on a scale of 1 to 5, with 1 being most negative and 5 most positive.

Query	Mean response	Std. Dev.
Rating of system as whole	3.8	0.7
Rating of usefulness of system	3.6	0.9
Easy to learn and use	4.2	0.7
Ease of privacy concepts	3.4	1.0
Ease of finding people and distances	3.9	1.1
Ease of finding event participants	4.1	0.9
Ease of creating event	4.6	1.0
Terminology	4.0	1.0
Interface pleasantness	4.0	1.0
Would you buy it?	5 Yes / 4 No	N/A

Integration with other applications and functions on the devices was mentioned by the majority of participants: being able to switch seamlessly from event planner to contact list and to phone is considered an essential feature of these designs. Integration is also a characteristic of highly successful systems like PalmOS and Symbian.

Undo was a sorely missed function. During design, undo was discarded in view of the fact that the device should be kept as simple as possible, and that interaction is structured to proceed in small, discrete steps. However, even for such simple and apparently harmless interactions steps, users need to undo or at least confirm specific actions: mobile applications are no different from desktop in this regard.

The subjective appreciation measures in the post-task questionnaire (Table 2), such as ease of learning and use and the ease of creating events, were ranked particularly positively. This confirms the choice of structuring the application around clear conceptual entities. Participants rated privacy concepts least easy to grasp; this feedback, in addition to observations and discussions with users, motivated reconsideration of privacy features in the second design iteration. The interviews aimed at gathering impressions and feedback on issues exposed during testing and unfulfilled expectations (e.g. the question: “Was there anything you wanted to do but couldn’t?”).

As a final comment, it should be noted that, in this early formative evaluation of a novel application, *qualitative data provided far more information than quantitative measures.*

## 4 Redesign

The redesign process sought to preserve the successful portions of the interface while making it faster to use, clearer, and more consistent through extensive rework of both position and labeling of interface elements, tighter integration and an optimization of the information presentation. Improvements include reworking of the top menu bar and the privacy-options screen, improvements to maps, and redesign of the “People” screen. Updated designs were built and shown informally both to users who had seen the old product and to others who had not, with encouraging comments, but a new test would be necessary to evaluate the effectiveness of the changes.

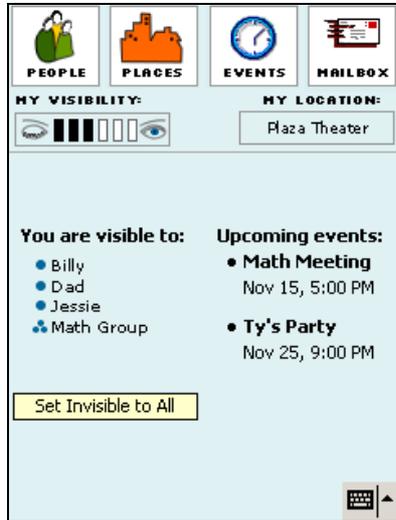


Fig. 7. Redesigned home screen



Fig. 8. Redesigned people screen

**Interaction design.** Participants had difficulties in renaming the anonymous GPS coordinates to meaningful locations, and were unable to use these “semantic locations” in their messages and meeting invitations. We sought to make these functions more intuitive, adding a full-sized “Places” button, to make the Place management more accessible. We integrated the secondary navigation bar (which contained the old “rename” button as well as a privacy indicator) into the button bar, making the privacy-level indicator more informative and the “My Location” area actionable and more understandable. (Fig. 7.)

A new incremental visibility indicator, that uses the more intuitive “watching eye” metaphor, was developed to address the shortcomings of the previous “privacy man”. A button was also added on the home screen to make the user invisible, to improve user performance and decrease the anxiety about privacy.

Graphical and more representational indicators are used in the buddy list. An “open eye” is used to inform whether a given individual can see the user or not, and groups have now a graphical representation. These replace the confusing and not well liked asterisk and plus signs that were used in the original application.

**Contact management.** The “People” screen, (Fig. 8) where users monitor visible buddies, view their address book and get further information like time, distance, and directions to buddy’s locations, has undergone considerable redesign. A tab was added for address book data, such as street addresses, phone numbers and email. Another tab provides a map view, while buttons allow the user to send messages, get detailed directions to a friend’s present location, and access a full-screen map.

Integration has also been enhanced: if a user is viewing an appointment, he or she can quickly “map the participants” to see the locations of the attendees. Similarly, it is

possible to send messages and make appointments directly from the People tab because the system remembers which buddy (or buddies) is being viewed when switching modes to send messages or invite buddies to informal events.

**Maps.** Test participants found maps useful for identifying others' locations, especially when they were familiar with the neighborhood. A legend was one of the proposals to enhance the maps in case of unfamiliar locations, and the redesign accounts for this. *The size and detail of maps in location-aware applications is critical.* In our preliminary testing, we found that users preferred simplified, color maps of the largest size afforded by a device. The initial design was driven by this consideration, and we increased the size of the map and decreased its complexity.

However, user feedback indicated that a legend was nevertheless necessary. The last version of the design uses a transparent legend, superimposed over the corner of the image, displaying current scale and people and places (Fig. 8). Since the size of the legend is proportional to the number of people displayed in the map, the legend would cover more and more of the screen as the number of people or groups increases. This could be solved by employing dynamic visualizations which show different elements (scale, legend, distances, detail) based on threshold values of the syntactic complexity of the map. Care was taken to make sure that maps served their purpose and were suited to the target form-factor but that they would convey just enough information for users to think with the map.

## 5 Lessons learned

The mobile personal communication device market is increasingly flooded with devices which are crossing the boundaries between mobile and pervasive computing [16]. In the long term, the rapid development of interoperable ubiquitous computing technologies makes it hard to predict the acceptance of services.<sup>6</sup> However, looking at the short term, it is possible to draw some considerations which might help in creating new and more compelling services.

While the developer community has embraced in the past couple of years a “program once, run anywhere” approach to advanced services on mobile devices, by creating automatic trans-rendering engines that format the same applications for different types of user terminals [10] [13], it is becoming apparent that a given application can be used fruitfully only on a specific hardware combination. For example, a map-based direction finder PDA might not be adopted by car drivers, due to ergonomic limitations such as bad lighting, low contrast and small screen, and the considerable attention focus required by a PDA, while it could be accepted by pedestrians, who are able to focus on the device while walking, without risk of accidents. The same service might thus be successful in dense European and Asian urban environments, and not in the United States, where people mostly need directions while moving in an automobile. *Mobile applications need to be developed for specific user, environmental and*

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<sup>6</sup> The telecommunications industry history is populated by spectacular failures of supposedly successful technologies. (WAP, Videotel, DECT)

*technological targets* and not as simple reduction of other applications (e.g. web-based).

In addition to the traditional usability paradigms [5] and evaluation heuristics [12], the design of resource-constrained mobile devices requires considering a broader spectrum of usability paradigms, among which *task resumability* and *integration*.

The ability of easily restarting tasks after an interruption or break is fundamental. This consideration stems from the observation of user activity on the prototype in an outdoor environment: our participants often interrupted their activity to look around, greet acquaintances, or respond to environmental stimuli, like a car passing by. This “task resumability” property is influenced by state visibility and task predictability, but also requires supporting the user in recovering the memory of system state and previous activity after a distraction. Design guidelines for supporting this include:

- stateless interaction model;
- visibility of the information needed to perform actions at any given step;
- atomic or short interaction sequences (requiring not more than a couple of steps);
- appropriate timeout on unfinished operations.

Integration also plays a fundamental role in mobile applications, because of the lack of a clipboard for temporary storage and the difficulty of taking notes to channel outputs to other applications on the device. Not only does integration ease task migration between user and system, but results in lower interaction times.<sup>7</sup> In the prototype, participants continuously asked for more features to be integrated in the system, such as being able to obtain navigation instructions, maps, or to call automatically a party based on location information. Mobile applications should afford this by:

- including hooks for moving from one interaction to another carrying intermediate data (e.g. when mapping a buddy’s location, the selected buddy becomes the “to” line for SMS messages or event invites);
- switching among application components and resume where the user left off;
- integrating the use of data to reduce the need of accessing multiple sources (e.g. by providing location information in the buddy list).

Privacy was a major concern of almost all participants: we will not discuss this here, given the availability of dedicated studies on the matter [9]. We only would like to point out that in the case of this prototype the iconography related to privacy functions did not provide enough clues for the participants to assess their “privacy state”. Usability problems of privacy enhancing technology are not new [19], and this study reiterates the need for a uniform and meaningful iconography and mixed iconographic/textual interfaces. Privacy is not a binary state (hidden/visible), but a range on the number of people that can see the user at a given time and here two designs were offered to represent this (the unsuccessful privacy “man” and the newer “eye bar”). Designs should also account for reflexive (where coupled partners are always either visible or invisible to each other) and non-reflexive privacy (which allows independent visibility, as in our application). *Privacy is both continuous and non-reflexive in the physical world. Location-aware designs should reflect this.*

In our system, users may label points that they visit, storing them for later use by them or their buddies. In doing this, the system implicitly draws the distinction be-

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<sup>7</sup> Execution time is an important factor when interaction is limited to “interstitial” moments between other activities, such as walking, taking a bus, paying for coffee, etc.

tween a location, which is any point in a given geography, and a place, which adds a meaning to a location, (which can be as simple as a label): *both abstractions are necessary in location-aware applications.*

Training has been necessary in usability tests where participants were supposed to represent a population of expert users, and reliable data needed to be unbiased by varying previous experience. As one of the aims of this study was to understand how quickly participants would be able to pick up the main concepts and functionality of the application, we did not provide any training. The drawback of this choice is that participants had problems understanding some aspects of the UI functionality: training on the specifics of the interface interaction model would have helped test participants into exposing the true learning time of the application.

Closely related to this is the problem of the *lack of quantitative historical metrics* for these new applications. While it is possible to base the comparison on the time spent in performing similar operations with ‘traditional’ alternative means, this is not very informative. On the one hand, with the event planner one may well communicate with a large number of acquaintances with one single operation, but the overall effect is very different from calling up each person individually: new applications elicit new behaviors and allow activities which have different mechanical and social effects.

On the other hand, basing the entire evaluation on raw timing measurements could prove to be very limiting, especially if the tasks are benchmarked in a situated action setting. Timings are important, but other performance measures such as resiliency to interruptions and interactions suspensions may be much more useful for evaluating this class of applications. Mobile and ubiquitous computing applications lend themselves well to situated action, activity theoretic or distributed cognition user models [1]; which of these are best for a particular application depends largely on the kind of application and of which aspects of the design are in the limelight.

The choice of a user model should thus be based on a critical analysis of the users and their knowledge, the tasks, and the application domain; this choice influences both the design and the evaluation of the system via a direct mapping with the system model. This evaluation design mainly used the situated action model, as we wished to examine the behavior and performance of users in real-world situations, where environmental and social factors are a source of both distraction and motivation [17]. We feel that this choice has been confirmed by the meaningful results of the evaluation.

## 6 Conclusions

Advancements in mobile computing have lacked the focus of blending with the everyday lives of people: it is essential not only to understand how people carry out their tasks but also to recognize how individuals use technology to build integrated applications rather than creating yet another artifact for people to worry about. User involvement is necessary especially for mobile computing – these products need to adapt to the rhythms of everyday life and the changing conditions of outdoors, leisure and informal settings. Early testing of applications in an ethnologically valid environment is vital, not only for developing better products, but also for understanding which applications will meet commercial success.

Moreover, it is necessary to test user and system models on specific mobile applications and their use in a noisy outdoor and informal environment, in order to understand which models are most appropriate. This work suggests that some common usability guidelines and evaluation metrics might not transpose from the desktop to the new breed of “disappearing hardware”. While a historical base of performance measures is necessary to reliably assess future designs, recognizing the inadequacy of raw performance metrics might be even more important, to focus on people needs and expectations.

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## References

1. Abowd, G., et al.: The human experience. In *IEEE Pervasive Computing*, 1(1), pp. 48–57, 2002.
2. AT&T Wireless: “Find Friends”, <http://www.attws.com/mmode/features/findit/FindFriends/>
3. Chincholle, D., et al.: Lost or Found? A Usability Evaluation of a Mobile Navigation and Location-Based Service. In *Proc. Mobile HCI 2002*. Pisa, Italy, pp. 211–224.
4. Colbert, M.: A Diary Study of Rendezvousing: Group Size, Time Pressure and Connectivity. In *Proc. Mobile HCI 2002*. Pisa, Italy, pp. 21–35
5. Dix, A., et al.: *Human Computer Interaction*, 2<sup>nd</sup> Ed.. Prentice Hall Europe, pp.162–175.
6. Federal Communications Commission: Enhanced 911, <http://www.fcc.gov/911/enhanced/>
7. Geser, H.: Towards a Sociological Theory of the Mobile Phone. University of Zürich, Switzerland, August 2002 (Release 2). [http://socio.ch/mobile/t\\_geser1.htm](http://socio.ch/mobile/t_geser1.htm)
8. Hibino, S., Mockus, A.: HandiMessenger: Awareness-Enhanced Universal Communication for Mobile Users. In *Proc Mobile HCI 2002*. Pisa, Italy, pp. 170–183.
9. Langheinrich, M.: Privacy Invasions in Ubiquitous Computing. Workshop on Socially-informed Design of Privacy-enhancing Solutions in Ubiquitous Computing. *UbiComp 2002*, Göteborg, Sweden.
10. Microsoft: Mobile Internet Toolkit 1.0 for Visual Studio .NET. <http://msdn.microsoft.com>
11. Nardi, B.: Studying Context: A Comparison of Activity Theory, Situated Action Models and Distributed Cognition. In *Context and Consciousness: Activity Theory and Human-Computer Interaction*, Nardi, B., Ed., 1996, MIT Press
12. Nielsen, J.: Enhancing the explanatory power of usability heuristics. In *Proc. of CHI’94*, pp. 152–158.
13. Nokia: Mobile Internet Toolkit 3.1. <http://www.forum.nokia.com>
14. NTT DoCoMo: Imode Information. [http://www.nttdocomo.co.jp/english/p\\_s/imode/](http://www.nttdocomo.co.jp/english/p_s/imode/)
15. Piller, C.: The Place That Tech Forgot, Los Angeles Times, October 19, 2000. [http://www.technovative.com/ourpress\\_latimes.html](http://www.technovative.com/ourpress_latimes.html)
16. Satyanarayanan, M.: Pervasive Computing: Vision and Challenges. *IEEE Personal Communications*, pp. 10–17, August 2001
17. Taylor, A., Harper, R.: Age-old Practices in the ‘New World’: A study of gift-giving between teenage mobile phone users. In *Proc. of CHI 2002*, pp. 439–446, ACM Press
18. UMTS Forum, Enabling UMTS / Third Generation Services and Applications, UMTS Forum Report 11, October 2000, <http://www.umts-forum.org>
19. Whitten, A. and Tygar, J.D.: Usability of Security: A Case Study. Technical Report CMU-CS-98-155, Carnegie Mellon University, December 18, 1998