2012 15th International Conference on Network-Based Information Systems

A Location-based Personal Task Management Application for Indoor and Outdoor Environments

Chi-Yi Lin, Ming-Tze Hung, and Wei-Hsun Huang
Dept. Computer Science and Information Engineering
Tamkang University
Taipei, Taiwan, R.O.C.
chiyilin@mail.tku.edu.tw, 699410626@s99.tku.edu.tw, 600420094@s00.tku.edu.tw

***Abstract*—Personal task management has been essential for modern people, in order to remind them of something at a specific condition. Reminders based on the electronic calendar in cellphones are popular, but such reminders are mostly triggered by time. It is also common that some tasks are only meaningful to be performed at a specific location, so it would be useful if reminders for those tasks can be triggered only when the person to be reminded is physically near or located at that location. Therefore, in this research we implement a location-based personal task management application for Android-based smartphones and tablets. To distinguish our work from existing ones that rely solely on the GPS technology, we take advantage of the ubiquity of IEEE 802.11 WLAN (Wi-Fi) infrastructure to compliment the blind spots of GPS location sensing. Combining the two technologies make it possible for the personal task management application to be effective in both indoor and outdoor environments. Furthermore, as long as the WLAN infrastructure is available, this application can be further extended to be used in many other scenarios which comprise both indoor and outdoor environments, such as guiding in public transportation systems or tourist attractions.**

Keywords-location-based services; GPS; Wi-Fi; RSSI

I. INTRODUCTION

In nowadays, many people are overwhelmed by numerous tasks waiting to be done. Tasks are of a wide variety, ranging from daily tasks such as meetings at work, to non-daily tasks such as buying groceries after work. To help reminding oneself of these tasks, common practices are to take notes on the paper-based day planners, or to use personal task management software on computers and/or cell phones so as to take notes electronically. The latter, which is getting more and more popular recently, benefits by the fact of increasing penetration of smartphones. According to [1], in 2013 smartphone shipments will rise to account for more than half of all cellphones for the first time. Tablet PCs such as Apple iPad and Google Android-based tablets also boost the use of personal task management applications in our daily life.

In general, various tasks can be classified into two categories: 1) *time-based* tasks, 2) *location-based* tasks. If a task is time-based, we mean that the task should begin at a specific time, such as a meeting scheduled at 10AM during weekday. To remind ourselves of this kind of tasks, we can set an alarm in the personal task management application, to make a "just-in-time" prompt before the meeting is about to start. On the other hand, if a task is location-based, we mean that the task should be performed at a specific location, such as to buy a bottle of milk at the convenient store nearest to your home. In this case, setting an alarm triggered by time may not be appropriate if you are not sure when you will be passing by the convenient store. This motivates us to design a location-based personal task management application, which can provide a "just-in-place" prompt to users. That is, in the above scenario, the alarm will beep as a reminder when you are getting close to the convenient store.

In fact, the concept of a location-based reminder is not brand new, which is merely one of the examples of the so-called *location-based services* (LBS). Nevertheless, we found that most existing location-based reminder applications rely solely on the Global Positioning System (GPS) technology to sense the location, which limits the effectiveness of such applications. Specifically, GPS uses line of sight to satellites, so it does not work when a user is indoors or in other circumstances when the line of sight is obscured. Although Assisted GPS (A-GPS) can help to some extent, it requires the support from the infrastructure of mobile operators. Therefore, we choose another approach – IEEE 802.11 WLAN, to complement the "blind" spots of GPS location sensing.

The IEEE 802.11 WLAN technology, also known as "Wi-Fi", has been massively deployed around the globe. Take Taiwan as an example, airports, train stations, museums, homes, hotels, campuses, restaurants, convenient stores, offices, and even main streets, are deployed with WLAN Access Points (APs). Moreover, most of the latest smartphones and tablets are equipped with both a WLAN interface and a GPS receiver. Based on these observations, we find it feasible to implement a location-based task management application in the smartphones and tablets, which combines the GPS and IEEE 802.11 WLAN technologies for location sensing.

978-0-7695-4779-4/12 $26.00 © 2012 IEEE
DOI 10.1109/NBiS.2012.108

The rest of this paper is organized as follows. In Section II we will describe the related work. The design of our location-based task management application is shown in Section III. The implementation and experimental study of this application is then shown in Section IV. The conclusions of this work are presented in Section V.

II. Related Works

In this section, we review some related technologies and previous works on the topic of location-based reminders.

Geolocationing is the first step to providing location-based services. Common locationing technologies include GPS, Wi-Fi, Cellular, Bluetooth, Infrared, and Radio Frequency Identification (RFID), to name a few. The applicable environment for these technologies varies, and their locationing accuracy also varies, so there has been a great deal of researches aiming at improving the two factors. Using a single locationing technology, Ni *et al.* [2] improved the locationing accuracy of RFID by deploying reference tags in the field. Locationing accuracy can also be improved by combining two or more locationing technologies. For instance, [3] and [4] use both GPS and Wi-Fi, and [5] uses RFID, GPS, and Cell-ID. However, Bhasker *et al.* [6] took a different approach by employing user feedback to correct system geolocations with low computation overhead, and their experimental results show very good accuracy in indoor environments. In terms of the applicability of locationing technologies, our previous work [7] combines GPS and RFID to make a logistics management application applicable for an entire itinerary consisting of both outdoor and indoor environments.

Sohn *et al.* [8] designed a location-based reminder application named “Place-Its”, running on the Symbian S60 mobile phones. They emphasized that compared with post-it notes or PDAs, mobile phones are a convenient and truly ubiquitous platform as the delivery of reminders. Through their experiments, they found that using one’s location to trigger reminders is a valuable piece of context to improve the way people use reminders, regardless of the fact that the locationing accuracy of mobile phones is relatively low. They also observed that location was widely used as a cue for other contextual information which is difficult to be detected by any system, inferring the merit of location-based reminders. A similar work can be found in [9], where Ludford *et al.* developed a location-based reminder system named “PlaceMail”. Their field study shows the usefulness of such a system, and also discovers that effective delivery of reminders depends on people’s moving patterns and the geographic layout of the space. Location-based reminders can also be used for advertisements. Instead of pushing the advertisements unsolicitedly to mobile phone users, the work proposed by Li *et al.* [10] triggers reminders based on previous settings (interested products) by the user oneself.

Based on the findings of [8], we are motivated to improve the location sensing capabilities of mobile devices, to make location-based task management applications more viable in our daily life. Specifically, the daily schedule for most people includes both indoor and outdoor environments. That is, a practical location-based reminder shall support location sensing in both environments. Moreover, the user study in [8] pointed out that reminders triggered on departure were not satisfactory; the reminders came to users’ attention several kilometers away from where the reminders were needed. It is obvious that if we can make the location sensing more accurate, this kind of reminders can become more useful.

It shall also be noted that although there are a number of location-based reminders available at the Google Play, those applications suffer from the problem of inaccurate locationing in the indoor environment.

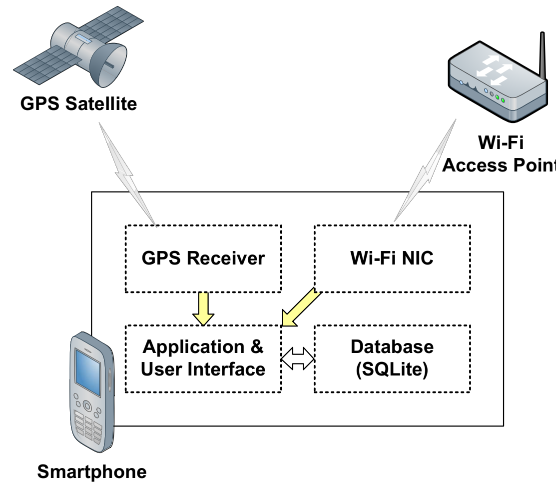

Figure 1. Schematic diagram of the proposed location-based personal task management application.

III. The Proposed Location-based Personal Task Management Application

A. System Architecture

The schematic diagram of our location-based personal task management application is shown in Fig. 1. There are mainly four hardware/software components in the smartphone, described as follows. The smartphone is built-in with both a GPS receiver and a Wi-Fi network interface, which can receive signals from GPS satellites and Wi-Fi APs, respectively. Based on the GPS readings and the information from the Wi-Fi APs, the application can perform geolocationing to estimate the current location of the user. The database is designed to store personally meaningful locations and location-based tasks, which are stored in separate tables. If a location-based task exists in the database, then the application will compare the sensed location with the location associated with the task. When the user is physically close to the predefined location, the reminder then will be triggered to remind the user of the task.

B. Indoor Locationing

As described in Section I, the deployment of Wi-Fi infrastructure is essentially ubiquitous in nowadays. By taking advantage of the fact, indoor locationing can be handily achieved by sensing the existence of some specific

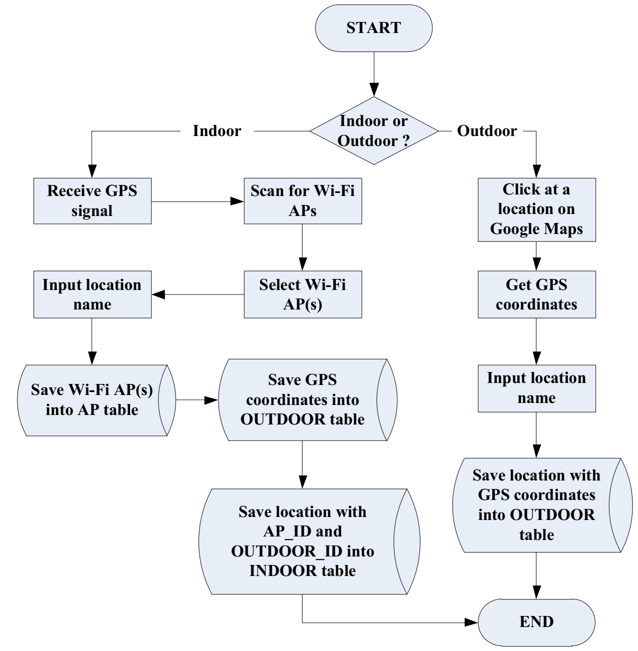

Figure 2. Flow chart for establishing personally meaningful locations.

Wi-Fi APs' wireless signals. Specifically, every AP will broadcast beacon frames periodically, which contain the MAC address of the AP and its service set identification (SSID). Therefore, a WLAN client can scan for the beacon frames to acquire the MAC address of the AP in vicinity, and then associate the MAC address with a personally meaningful location. In many cases, especially in urban areas, it is very likely for a WLAN client to discover multiple APs when scanning for wireless connections. Therefore, in our design we allow multiple APs to be associated with one location, to increase the accuracy of indoor locationing. However, it shall be noted that in our application the indoor personally meaningful locations must be pre-visited by the user. More precisely, the user must be physically located at the location, scan the Wi-Fi APs, then save the location into the application database. With this prerequisite setting, the users may create reminders and then associate them with the pre-established locations.

C. *Outdoor Locationing*

For outdoor locationing, we utilize the most popular locationing technology – GPS. To ease adding a personally meaningful location into the database, we use Google Maps as the user interface in our application. That is, by clicking at a specific location on the Google Maps, users can add that location into the database and then use it in location-based reminders. Different from the location database for the indoor environment that associates locations with MAC addresses, the location database for the outdoor environment associates locations with their GPS coordinates. Besides, since the GPS coordinates of the outdoor personally meaningful locations can be obtained from the Google Maps API, users are not required to be physically located at those locations before using them in their reminders.

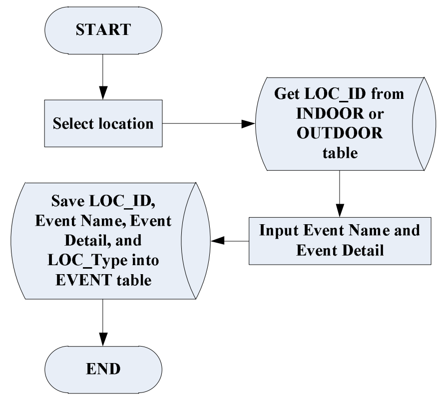

Figure 3. Flow chart for creating location-based reminders.

D. *Flow of Operations*

There are three steps of operation in the proposed personal task management application:

Step 1. Users establish personally meaningful locations
Step 2. Users create location-based reminders
Step 3. The application triggers the reminder when user is at the predefined location

The detailed flows of the three steps are shown in Fig. 2, Fig. 3, and Fig. 4, respectively. In Fig. 2, we can see that indoor and outdoor personally meaningful locations are established differently. As described previously, indoor locations can be associated with Wi-Fi APs. However, in our implementation we chose to associate each indoor location with both the Wi-Fi AP information and the GPS information. We'll explain later why this is needed. Once a location is established, it can be used in setting a location-based reminder. As shown in Fig. 3, creating a location-based reminder is fairly straightforward: choose a location, edit the event name and details, done. After reminders are created, the application follows the process shown in Fig. 4 for triggering the reminders. The application keeps reading the GPS signal and comparing the current GPS coordinates with those in the OUTDOOR table. Once a match is found and the LOC_Type of the matched record is "*Indoor*", then the application scans for Wi-Fi APs and tries to find a match in the INDOOR table. If a match is found and there's at least one event (i.e., reminder) associated with the matched indoor location, then the application triggers the reminder immediately. If the above-mentioned LOC_Type of the matched record is "*Outdoor*", then the application checks the EVENT table directly to determine whether to trigger a reminder.

Now we'd like to elaborate on our design of associating indoor locations with both the Wi-Fi APs and the corresponding GPS coordinates. The benefit is two-fold. First, indoor locations with the GPS coordinates can be pinpointed on the Google Maps. Therefore, users can view the Google Maps user interface in our application to look at

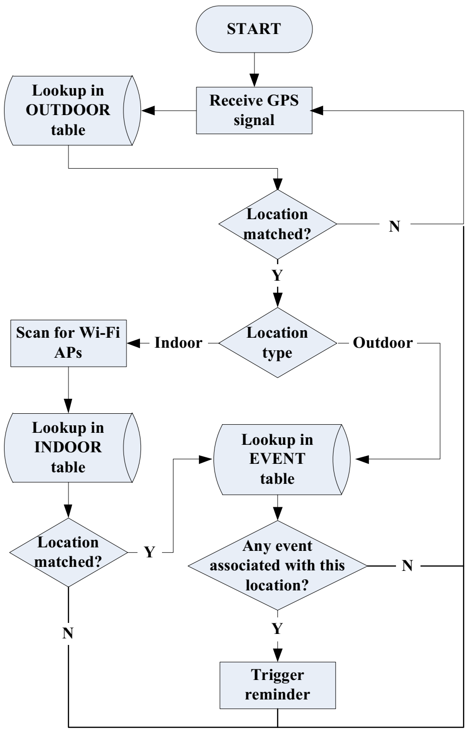

Figure 4. Flow chart for triggering location-based reminders.

Figure 5. The map UI of the application.

the events they have already created. It gives the users a unified user experience, no matter the event is associated with an indoor or an outdoor location. Second, if an indoor location is only associated with the Wi-Fi AP information, the application needs to scan the APs all the time for indoor location sensing, which may incur considerable power consumption to the smartphones and tablets. With the GPS coordinates of the indoor locations, only the GPS receiver needs to be always on, because Wi-Fi scanning will not be enabled until a location match in the OUTDOOR table is found.

IV. Implementation and Experimental Study

In this section we describe the implementation and experimental study of the proposed location-based task management application.

A. Implementation

We developed the location-based task management application using the Eclipse IDE with Android Development Tools (ADT) plugin, and tested it on an ASUS Eee Pad Transformer TF101 with Android version 4.0.3. In the following we briefly introduce some important features of our implementation.

Fig. 5 shows a snapshot of the map UI, in which we can see three pin icons. Red and purple pin icons indicate the established outdoor and indoor locations, respectively, and the digit labeled in the pin icons indicates the number of events associated with that specific location. Beside the purple pin icon labeled 2 there is a light blue circle, which indicates the current location of the user. As we pointed out in Section III, since indoor locations are also associated with their GPS coordinates, they can be pinpointed on the map. Therefore, regardless of the locations are indoor or outdoor, users are able to see them through the map UI.

Fig. 6 shows a snapshot of adding an indoor location. The message box over the up-right corner displays the number of detected Wi-Fi APs at the location. After the user enters the name of the indoor location and presses the "Save" button, this location is then established in the database. Note that during this process users are not hassled by the problem of selecting appropriate Wi-Fi APs to be associated – the application will do it automatically. Also note that in our implementation the received signal strength indicator (RSSI) of the Wi-Fi AP must be over −70dBm to be eligible for being associated with an indoor location. If the measured

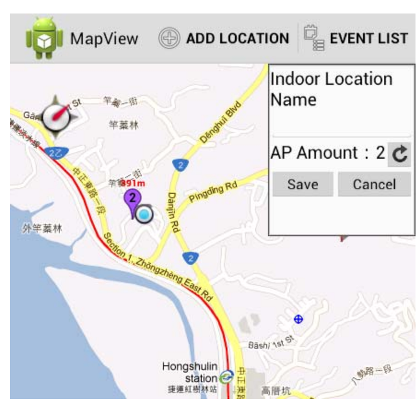

Figure 6. A snapshot of adding an indoor location.

RSSI of a Wi-Fi AP is lower than −70dBm, it normally means that the AP is far away from the user, and in this case the measured RSSI can fluctuate severely. For this reason, we only associate those APs that are closer to the user, so the measured RSSI will typically be more stable. Furthermore, in order to make indoor locationing more accurate, the measured RSSI value of each Wi-Fi AP during location establishment is also saved into the database. When performing location sensing, a specific Wi-Fi AP is declared to be matched only when the measured RSSI value of this AP falls into the zone of "saved RSSI ± δ". For simplicity currently we use a fixed δ value of 5. The concept of this methodology resembles that of the location fingerprinting approach [11], which utilizes a radio map built in the offline phase to assist locationing. That is, if the measured RSSI is within the region, it means that the user is very likely to be physically close to the same spot where the user established the indoor location previously.

B. *Experimental Study*

Since the indoor locationing depends on the RSSI values, we performed an experiment to measure the RSSI values at various distances. At each distance we measured the RSSI values for 1000 times at the rate of one RSSI value every three seconds. The result is plotted in Fig. 7, where at each distance the average value is labeled using the diamond icon, and the blue and the red bars show the range of the standard deviation (σ) and 2σ, respectively. The regression line (orange curve) clearly shows the tendency of RSSI values with respect to the distance from the Wi-Fi AP. We can also observe that the standard deviation grows larger with the distance.

C. *Discussions*

As described in Section III, our application requires that the indoor personally meaningful locations must be pre-visited by the users prior to using these locations in a reminder. Although this requirement seems to be a weakness in usability, it may not be an issue if the indoor locations are those visited by the users on a daily basis, such as users' homes and offices. Moreover, if the association of indoor locations with individual Wi-Fi AP information and GPS coordinates can be shared among social communities, the usefulness of this application will be increased.

Regarding the δ value used in Wi-Fi AP matching, we mentioned that it is currently a fixed value. From the experimental result shown in Fig. 7, it can be a viable solution to make the δ value equal to 2σ, assuming that the measured RSSI values follow the normal distribution. Doing so can make the indoor location sensing more accurate.

V. CONCLUSIONS

In this research, we implemented a location-based task management application for Android-based smartphones and tablets. Compared with the existing works, the main feature of our application is that users can reminded of his/her tasks at both indoor and outdoor locations, with the aid of the built-in GPS receiver and the WLAN network interface. Furthermore, our application gives users a unified user

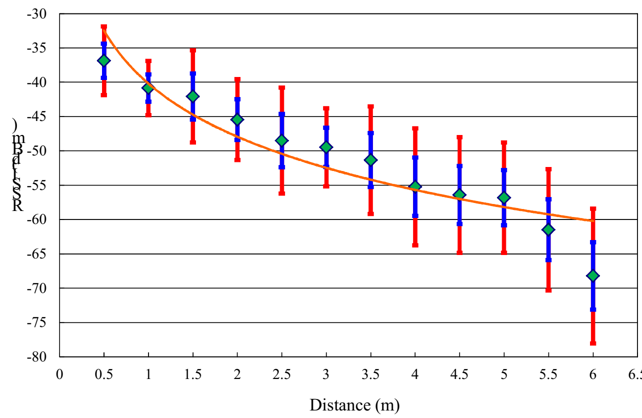

Figure 7. Measured RSSI vs. distance to the Wi-Fi AP.

experience because all the established personally meaningful locations can be displayed on the map UI regardless of the location types. As long as the WLAN infrastructure is available, we believe that this type of applications can be further extended to be used in many other scenarios which comprise both indoor and outdoor environments, such as guiding in public transportation systems or tourist attractions.

ACKNOWLEDGMENT

This research is supported in part by the National Science Council, Taiwan, R.O.C., under grant number NSC 99-2221-E-032-030-MY3.

REFERENCES

[1] W. Lam, "Samsung Overtakes Nokia for Cellphone Lead," Press Release of iSuppli, April 26, 2012, available at: http://www.isuppli.com/Mobile-and-Wireless-Communications/News/Pages/Samsung-Overtakes-Nokia-for-Cellphone-Lead.aspx

[2] L. M. Ni, Y. Liu, Y. C. Lau, and A. P. Patil, "LANDMARC: Indoor Location Sensing using Active RFID," *Wireless Networks*, vol. 10(6), pp. 701-770, 2004.

[3] R. Hansen, R. Wind, C. S. Jensen, and B. Thomsen, "Seamless Indoor/Outdoor Positioning Handover for Location-Based Services in Streamspin," *Proc. 10th Int'l Conf. Mobile Data Management: Systems, Services and Middleware*, pp. 267-272, May 2009.

[4] P. Bahl and V. N. Padmanabhan, "RADAR: An In-Building RF-based User Location and Tracking System," *Proc. 9th Annual Joint Conference of the IEEE Computer and Communications Societies (INFOCOM)*, pp. 775-784, Mar. 2000.

[5] X. Chen, D. Yu, and H. Wang, "Design and Implementation of Logistics Information Terminal Positioning Technology," *Proc. 4th Int'l Conf. Wireless Communications, Networking and Mobile Computing*, pp. 1-4, Oct. 2008.

[6] E. S. Bhasker, S. W. Brown, and W. G. Griswold, "Employing User Feedback for Fast, Accurate, Low-Maintenance Geolocationing," *Proc. 2nd IEEE Int'l Conf. Pervasive Computing and Communications (PerCom 2004)*, pp.111-120, Mar. 2004.

[7] C.-Y. Lin, W.-T. Cheng, and S.-C. Wang, "An End-to-End Logistics Management Application over Heterogeneous Location Systems," *Wireless Personal Communications*, Vol. 59(1), pp. 5-16, Jul. 2011.

[8] T. Sohn, K. A. Li, G. Lee, I. Smith, J. Scott, and W. G. Griswold, "Place-Its: A Study of Location-Based Reminders on Mobile Phones," *Proc. 7th Int'l Conf. Ubiquitous Computing (UbiComp 2005)*, LNCS 3660, pp. 232-250, Sep. 2005.

[9] P. J. Ludford, D. Frankowski, K. Reily, K. Wilms, and L. Terveen, "Because I Carry My Cell Phone Anyway: Functional Location-Based Reminder Applications," *Proc. ACM SIGCHI Conf. Human Factors in Computing Systems (CHI 2006)*, pp. 889-898, Apr. 2006.

[10] Y. Li, A. Guo, S. Liu, Y. Gao, and Y.-T. Zheng, "A Location Based Reminder System for Advertisement," *Proc. 18th ACM Int'l Conf. Multimedea (MM 2010)*, pp. 1501-1502, Oct. 2010.

[11] P. Bahl and V. N. Padmanabhan, "RADAR: An in-building RF-based user location and tracking system," *Proc. 9th Annual Joint Conference of the IEEE Computer and Communications Societies (INFOCOM)*, pp. 775–784, March 2000.