

LOCATION-AWARE PERSONAL LIFE CONTENT MANAGER AND ITS PRIVACY FUNCTIONS

Hideki Kaji* and Masatoshi Arikawa

Center for Spatial Information Science, The University of Tokyo
5-1-7 Kashiwanoha, Kashiwa-Shi, Chiba 277-8568 Japan
(kaji, arikawa)@csis.u-tokyo.ac.jp

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ABSTRACT:

In this paper, we will introduce a location-aware personal life content manager (laPLCm) and the functions of location privacy for data representation, query, transmission and positioning methods on laPLCm. laPLCm allows users to be reminded and access their own personal life content by spatial keys of the content and the users in their real lives. Examples of personal life content representing past, present and future events are diary, schedule, to-do list, GPS logs, photos and videos which are recorded, created and stored with our daily mobile devices. Personal life content cannot be fully treated on current commercial LBS. Our proposed laPLCm gives a new platform for users to easily generate their own LBS for themselves, their families, friends and colleagues using their personal life content in the form of blog as well as original privacy functions. The functions of setting levels of information sharing to each of persons and groups flexibly realize part of the privacy for data in our system. Personal mapping services introduced in the paper prevent from recoding positions of users in the servers of web mapping providers. Our proposed self-positioning methods are also significant to keep the location privacy for positioning methods. Furthermore, we demonstrate our prototype system based on the architecture of location privacy, and discuss usability, feasibility and sustainability for the system with comparison of present commercial LBS.

1. INTRODUCTION

Location based services (LBS) grow popular and many people use these kinds of services on their mobile phones and other mobile devices with GPS receivers. For example, users can find their positions on maps, search points of interest (POI) around them, generate itineraries of their trips using complex time tables of public transportation, and navigate in the real world (Arikawa et al., 2007). On the other hand, there are many users who fear a lack of security and privacy of their location information (Dobson et al., 2003; Nouwt, 2008). These users think service providers may estimate their activities and movement patterns in life from their location information if they keep using commercial LBS.

On the Internet, people make personal life content, for example records of dairy activities, their opinions for interesting things, to-do lists and schedules as user generated contents like blog, twitter (Twitter, 2009), SNS (Boyd, D. et al., 2007) and video/photo sharing services. These systems have various privacy policies and features for privacy setting so users can control sharing level of their content. One of the reasons why people keep recording on blogs is not only informing other users about author's opinions, but also retrieving them as needed (Nardi et al., 2004). Most of the records, however, might never be accessed in their lives, and many of these personal records include spatial information which can be provided as spatial content in LBS. From this point, we

developed and started experiment of blog based location-aware personal life content manager (laPLCm). laPLCm can provide users with their personal information or services based on locations and their personal information which are managed in blog. Also, users can easily launch user-generated LBS for themselves as well as other users on the Internet. On the other hand, privacy factor becomes much more important when LBS have functions to treat personal life content. In this paper, we focus on privacy settings for our proposed laPLCm and our developed prototype system of it.

2. PRIVACY SETTINGS ON SOME SERVICES

In this section, we will introduce treatments of privacy on some Internet services.

2.1 Social Network Service (SNS)

SNS is one of the most popular services on the Web. It provides environments for building online communities. Boyd and Ellison defined that it allows individuals to (1) construct a public or semi-public profile within a bounded system, (2) articulate a list of other users with whom they share a connection, and (3) view and traverse their list of connections and those made by others within the system (Boyd, D. et al., 2003). Facebook (Facebook, 2009) is a popular SNS that was designed for communication between students at first. It has simple privacy setting for sharing user's profiles. Users can set

* Corresponding author. This is useful to know for communication with the appropriate person in cases with more than one author.

statuses to each attribute like basic information (e.g. sex, birthday, home town and political view), self introduction (e.g. activity, hobby, music, TV programs) and friend list to limit accessing from other users. Users can choose a restriction status from four options.

- **Everyone**
- **Friends of Friends**
- **Only Friends**
- **Custom**

Authors can add restricted friends if you set the status to **Custom**. Furthermore, authors can set posting ability to their content from other users. This feature is easy to set restriction but it cannot set these statuses to each post separately so it has lack of flexibility

2.2 Google Latitude

Google Latitude (Google Inc., 2009a) provides an environment for sharing one's current location information and messages with Gmail (Google Inc., 2009b) users as a Web service. Its location sharing setting is very simple. Users set some sharing status of his/her location information for each Gmail contact. There are four statuses on acceptance of location information sharing.

- Accept and share back
- Accept, but hide my location
- Do not accept
- Block

Furthermore, users can choose a detail of location information from three levels

- Share best available location
- Share city level location only
- Hide from this friend

Additionally, users can set their location by manual pointing instead of using GPS. This setting feature is very simple, but it may take much time if you have a lot of Gmail contacts.

3. LOCATION-AWARE PERSONAL LIFE CONTENT MANAGER

We developed a prototype system to realize new Location-Aware Personal Life Content Manager (laPLCm). On this system, to create and store personal life content with location information, we adopted blog for a base system of the LBS server. We thought, blog had become popular on the Internet and many people have or had their own blogs. It is an easy way to make personal life content on the Internet. Thus, we decided to utilize location information on a new blog system so that users can create spatial personal life content easily. Furthermore, we selected mobile phones as a platform for LBS client applications. Latest mobile phones equipped with various features such as GPS receiver, motion sensor, digital compass, digital camera and network accessibility that provide a good environment for using spatial personal life content in the real world.

3.1 Architecture of laPLCm

Figure 1 shows the architecture of our laPLCm which is designed as an open platform to realize laPLCm based on protocols of the Internet. The system is constructed with the place enhanced blog and the LBS client on mobile phones. Our LBS server, that is, a place enhanced blog application is coded by Perl as a Web CGI application, thus they are working on Web servers and using HTTPS to communicate with Web

browsers and LBS clients. LBS clients connect the interface script to interactively retrieve, and display POIs from the place enhanced blog through user-friendly GUI on the screen of a mobile phone.

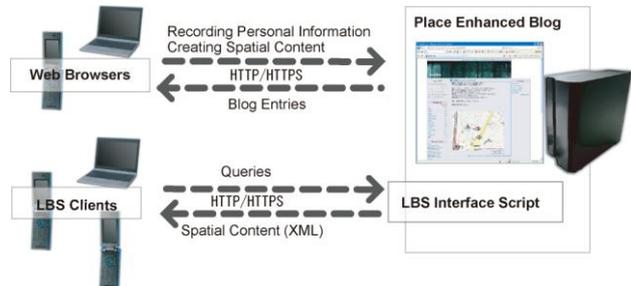


Figure 1. Architecture of pTalk, that is, the name of laPLCm.

3.2 Place Enhanced Blog

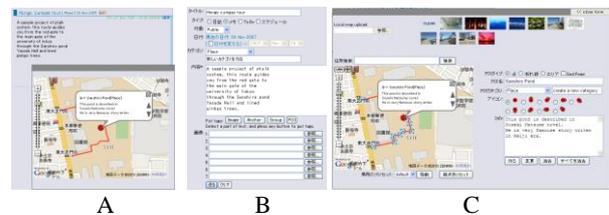


Figure 2. Entry view (A), entry input form (B) and place information input form (C). (Map images: copyright 2009 Google, copyright 2009 ZENRIN)

Place enhanced blog provides users with an extended function of dealing with spatial information such as point of interest (POI) and area of interest (AOI) in addition to general functions of common blog systems such as browsing and managing personal information. Users add place descriptions to their blog entries through blog input interfaces on Web browsers. To create an entry and corresponding place descriptions, users need to use two input forms, one is entry input form a simple input form same as normal blogs. Other one is a place information input form. Users can create multiple place objects on it. When users create a new place object, they point a target place on the map view and fill some fields for descriptions of this object. These place objects are included with this new entry (Figure 2).

3.3 Personal Map Content

On our system, instead of using map images from open global map services, users can use personal map images as base maps on LBS. Arbitrary uploaded images like hand drawn images, photos and captured facility maps are utilized for personal maps. A content using personal maps, personal map content, includes spatial objects same as global map content on our LBS, they are placed by local X-Y coordinates of a personal map. Additionally all spatial objects on our LBS are allowed to make a link to other spatial object on another global/personal map content. These links lead from a global content to a personal content, or represent connections between a personal content and other personal content. Using these links, users are able to go into personal map and go back to global map quickly. Furthermore, it is utilized to represent connections between facility maps of each floor and some buildings. (Figure 3)

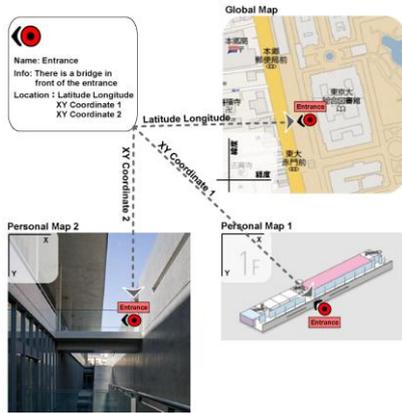


Figure 3. An example of linked POI on several personal maps.

Following two figures (Figure 4, 5) represent sample personal map content. Figure 4, this content uses a station's facility map. The facility map is not north up and it is a little complex to go to the north exit from platforms of super express train. It indicate a route to the north gate, and users can approach to the north gate easily by tracking the route (the red line) on this personal map content, when they arrive at this station by super express train.

Figure 5 represents pedestrian navigation content using sequential photos. To follow links of spatial objects is similar to turning over photos and users look for same landscape in each photo for self-positioning and self-navigation.

In personal map content, users only use self-positioning, but we think if entrance points are easy to recognize, users can adjust their positions by themselves, so they can continue walking in personal map content with our LBS client. Also personal map content does not use latitude-longitude coordinates for positioning, thus users can hide from logs of global map services.

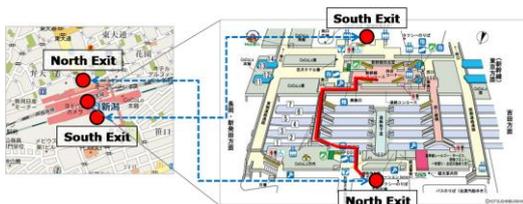


Figure 4. A personal map content using captured facility map that leads travellers from platform of super express to the north gate. (Facility map: (c) KOTSUSHINBUNSHA)

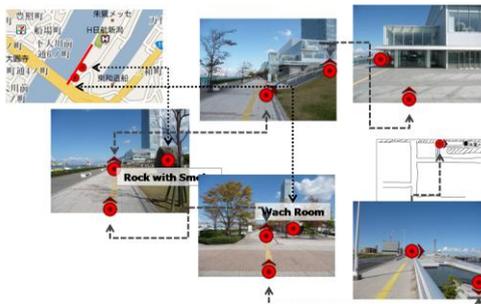


Figure 5. A personal map content by sequential photos. It represents a path from a bridge to a convention hall using sequential photos.

4. CONNECTION BETWEEN WORDS AND PLACE INFORMATION

On our blog, spatial information and a blog entry have a loose relationship normally. Sometimes multiple spatial objects, while a spatial object represents spatial information on a map, can be included in an entry, and blog readers need to find correspondence relationships between a part of the entry text and a spatial object from the context of the text. For setting an explicit relationship between a part of text and a place object and for assigning restriction levels for privacy to a spatial object, we prepared a pair of POI tags, [poi #] and [:poi]. A POI tag is composed of a start tag [poi #] including the number (#) represents a target spatial object, and an end tag [:poi] which consists of a colon and the tag word "poi". Owners can write descriptions with other various tags between the start and end POI tags. When a POI tags are embraced group tags, the target spatial object is assigned a limitation of data access for browsing. Thus, only permitted spatial objects of a reader are displayed on a digital map on a blog site and screen on a LBS client. Using this feature, users can add flexible restrictions of data access control to spatial objects.

On our blog, despite of using angle brackets "< >" for representing tags, it uses square brackets "[]". This avoids several security issues, for example, cross site scripting, session hijacking and so on, without any complicated process.

When a user makes mistype of control tags on his/her blog, layout and linking tags, [image] and [poi] don't have serious problem. But if users write wrong tag style on access control tags, group, it has possibilities of serious privacy leak. We think users can avoid it using some inputting and confirming functions. Thus we provide users with tags placing function places tags on head and tail of a selected substring then users need to add attributes to placed tags, and preview function before publishing a new entry on our blog. It will reduce mistypes and problems.

5. PRIVACY SETTINGS ON LAPLCM

5.1 Levels of Group Sharing for Blog Documents in Part

Our place-enhanced blog has sharing group settings same as some normal blogs and SNS. However, those blogs and SNS can set only one sharing level to each record, on our blog, authors can set flexible access restrictions not only whole text of each blog entry but also each word in the blog entry text using these sharing groups. For example, the following texts include access controlled partial texts. A writer can set a restriction level in part of the text for information sharing with all friends. A line headed by "A part" can be shown to friends of "Group A", a line of "B part" can be also accessed by friends of "Group B".

Today, I went to my office, 30km far from my house, by bicycle.

(A part) My office is [here](#)

It needed 2 hours to reach the office.

When I returned, I have spent 3 hours on the way because of fatigue and against wind

(B part) I'm sorry for late for the dinner party.

Users on the author’s friend list can show the following text.

Today, I went to my office, 30km far from my house, by bicycle.
 It needed 2 hours to reach the office.
 When I returned, I have spent 3 hours on the way because of fatigue and against wind

“Goup A” users on the list can show additionally the A part line. So, users of “Goup B” can show the B part line.

We will explain about sharing details and how to set restrictions to each word text. There are four levels and groups for sharing blog entries (Table 1). Sharing levels express of showing of each entry and arbitrary parts of the blog text. Sharing groups are defined as lists of users for sharing. Users can make multiple sharing groups on their accounts.

Table 1. Sharing levels of laPLCm

Sharing group / Sharing level				
Private				
Group1	Group2	Group3	Group4	...
Friend				
Unlisted / Public				

*Names of sharing level and group are same without Public level

Our proposed system provides enough functions of restrictions for users to access part of text by setting sharing levels. A user can assign all other users to a sharing group. **Group** level is separated into subgroups, and when a user is put in Group level, the user has to be put in a subgroup like “Group1”. Users can make arbitrary subgroups on Group level.

- Unlisted users can only show “Public” level contents.
- Friend level users can access “Public” and “Friend” level contents.
- Group level users can show “Public”, “Friend” and their included sub group level contents. For instance, if U is in Group1, U can show “Public”, “Friend” and “Group1” level contents.
- Private level users can show all content of this author.

When users set restrictions for blog text, first, an Author chooses sharing level of a blog entry. Second, put some pairs of group tag, [group foo] [:group], in the blog text for setting restriction to arbitrary parts of the text. Following text is the sample of usage of group tags.

(Whole text: Friend)
 Today, I went to my office, 30km far from my house, by bicycle.
[group A] My office is here[:group]
 It needed 2 hours to reach the office.
 When I returned, I have spent 3 hours on the way because of fatigue and against wind
[group B] I'm sorry for late for the dinner party.[:group]

Our blog provide flexible restrictions of blog texts with users using this group tags. A user just make a friend list on the user’s blog account to use this access control.

5.2 Personal Mapping Services

It is an important problem that locations of users are recorded to servers of commercial map providers when web mapping services are used from mobile computing environment with GPS receivers, because the queries to obtain map data around their positions mean that users always inform their positions to web mapping servers. Our proposed personal mapping services prevent from the recording of users' locations as the log of web mapping. The personal mapping services serves as proxy servers of web mapping services in additions to personal map repositories. If the personal mapping servers have cache data of maps of users’ interests which have been fetched from web mapping servers before, maps of their interests are available through the personal mapping services without any accesses to web mapping servers. If the personal mapping servers do not have cache data of maps of their interests to visit in future but their planned routes have already known for users and their navigation scheduler software, map prefetching transactions following the planned routes can be executed to store the cache data of maps of their interests in advance. The prefetching spatial queries can be recorded in web mapping servers, but real-time position tracking is prevented from recording. Also, the LBS clients on mobile devices can use secured private transmission protocol to make spatial queries to and to receiving spatial data from personal mapping servers. For example, cached map data can be transformed by intended differential coordinates as transmission data on the Internet. Furthermore, the spatial data transmissions between the LBS client applications and personal mapping server applications can be asynchronous to hide real-time positions of users.

5.3 Self-positioning

Our developing LBS client applications can cover indoor navigations using indoor map content and self-positioning function. GPS signal is usually not available indoor or is inaccurate. Our proposed self-positioning function allows users to easily set their position with natural computer-human interactions. Network data representing ways of both indoor and outdoor are used for the basis of the positioning. Users’ positions are on the ways. Default speed of users' movements may be three kilo meters per hour. The positions of users are automatically moving on the ways of the displaying map at the constant setting speed which can be easily changed. Also, users can stop, forward, and backward the movement of their positions using user-friendly interactions like a mobile music player. On branch points, users can easily choose their ways by simple selecting operations. The user friendly self-positioning interfaces can be considered tiresome, but many subjects do not feel tiresome in the operation of self-positioning. They felt fun the self-positioning like the operations of computer games. The self-positioning function is important for indoor LBS and navigation from location privacy as well as practical viewpoints for universal navigation systems. If users use the self-positioning, they need not communicate with global online positioning services, including assisted GPS, Wi-Fi Positioning and so no, which can record the real-time positions of users on the servers of global positioning providers.

Navigation on cars and other high speed or imbalance vehicles needs hi accurate positioning and correct information, because drivers need to watch and decide their direction in short time, if their position on navigation systems provide drivers with inaccurate information, it may happen traffic accident. On the other hand, pedestrians have more allowance to check and operate a mobile device to use LBS client, because they can stop walking and step aside any time. This means users can take time to match their position and choose useful information on LBS so we think it suits self-positioning and using unsure content on user generated content.

6. EXPERIMENT IN REAL SITES

We had an experiment to demonstrate the efficiency of our system as a location based service. We tried out the system in a class. Twelve graduate students of the University of Tokyo used our system. Students created town guide content on it, then they experienced these content on each site.

6.1 Creating Personal Spatial Content

Students created spatial content or town guide content as an assignment after a lecture using our system for an hour. The content was a walking guide for an area around Tokyo. Students created some entries including related POIs and lines on the place enhanced blog. POIs represent favourite restaurants, interesting hobby shops, view points and so on. Lines represent some route to walk the area.

Most students created their content in only one night. The target areas and numbers of spatial objects in the content are shown in Table 2. According to time stamps of each entry and access log of our Web server, they did not spend much time for creating their content.

Table 2. Numbers of Entries and Spatial Objects in each of Spatial Content Created by Students

	Route Count	POI Count	Entry Count	Making Time
S1	3	29	3	-
S2	3	27	30	2:40
S3	1	13	14	0:50
S4	3	22	25	4:00
S5	2	20	22	0:40
S6	1	20	21	1:00
S7	0	20	20	3:00
S8	1	7	7	0:30
S9	1	21	22	1:00
S10	2	20	22	1:20
S11	4	20	24	2:00
S12	0	13	13	2:30

*Time is a span from the first entry posted to the last entry posted. S1 did not post entries continuously thus S1's time is not filled.

6.2 Experience on the Sites

Students experienced the spatial content with each other using LBS client application on mobile phones. Current our LBS client application displays multiple points of interests with map images on screen. Users can read description of each point of interest and a text of corresponding entry in a window. If there is one or more dashed poly lines on map images, users can start scrolling maps along a poly line automatically by select and start walking on maps function. To retrieve place information around a user, it uses key word or a latitude and longitude coordinate that it is pointed by center point of the map view or GPS on a mobile phone. Additionally, users set down target users of our blog, target term and radius for searching. On the site, students tracked a route in the content and checked real places of POI described. They can choose arbitrary route and change his/her route to another any time.

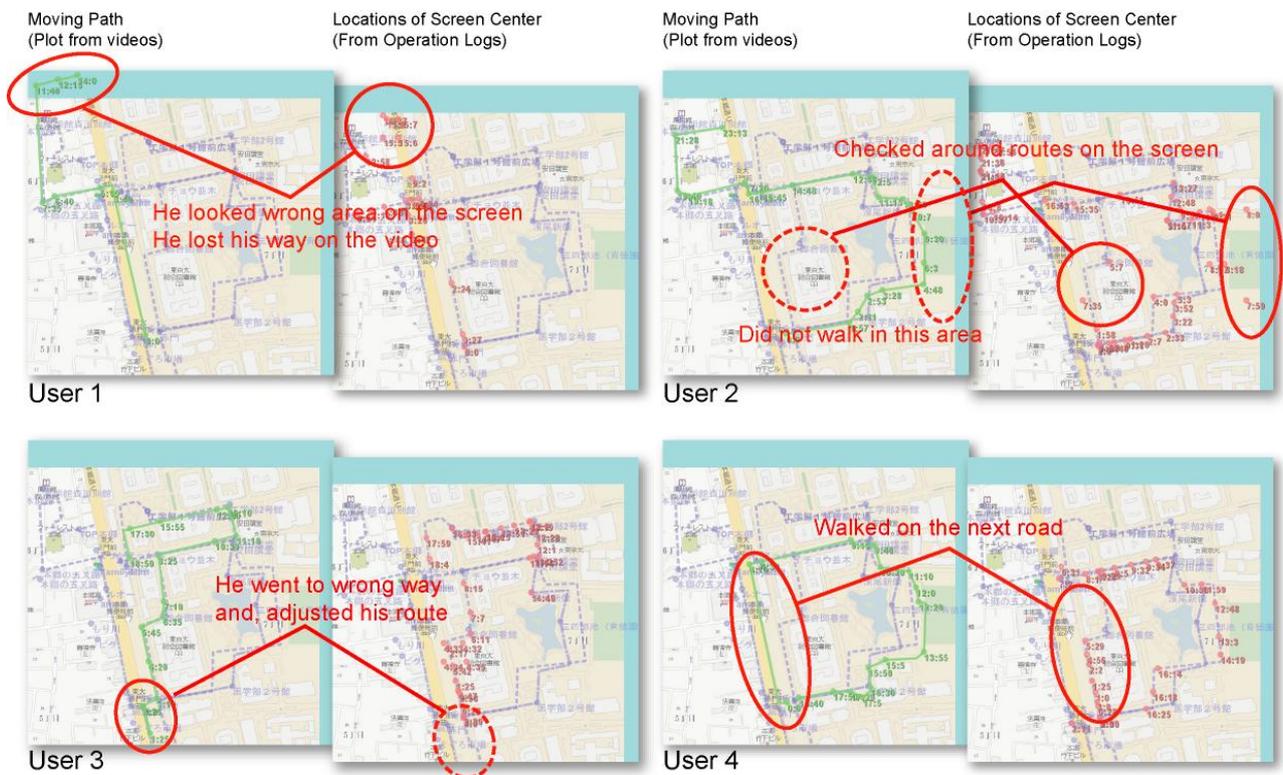


Figure 6. Walked paths and logged points of experiences on the Hongo Campus

Our prototype LBS client does not use GPS functions, thus its users must adjust their current positions on the map displayed the screens of their mobile phones. Some students lost their ways when they experienced the navigations of our LBS. There are some students' feedbacks after the experiment as follows:

- The mobile phone client took time to be getting used to.
- It is interesting to relive the experiences of someone else.
- I was prone to get lost with GPS-less navigation.
- It was easy and useful to create spatial information on the place enhanced blog.

Figure 6 shows some pair of plots of moving paths and plots of locations of screen center on maps that users used a content to guide around Hongo Campus of the University of Tokyo. Usually, these tester students are based on the Kashiwa Campus that is located 30km far from Hongo, and they are not familiar with the Hongo Campus. These maps represent user's matching accuracy and mismatching points in the experiences. On our system, users need to make self-positioning to reduce using GPS thus matching accuracy is an index of usability. Red circles mean characteristic points of user behavior. User2 used the client easily and he could walk in the campus along multiple routes without losing his way, furthermore he checked around routes using map scroll feature. User3, at first, went to wrong direction, but he realized his mistake soon and returned to the correct way. User4 walked on the next road of the target route then he adjusted his position at the junction of these two roads. User1 lost his way and he entered an area that maps of the area were not prepared on our prototype map server. Thus, he could not return to any route.

All students began to check the mobile phone continuously, when they missed their right locations. According to video records of their behavior, we presumed that they were checking their locations and spatial information around them, when they did not operate their mobile phones. Also, according to these points of Figure 6, it was easy for users to match their locations without GPS and other sensors, and it proved that our proposed route based navigation method worked well.

7. CONCLUSION

In this paper, we have proposed the laPLCm framework and reported our implemented prototype system of the laPLCm for using personal life content with reasonable privacy functions. The prototype system provided users with a useful environment to create and use personal life content with spatial information as an extended blog system. Then, we confirmed the effectiveness of our proposed laPLCm. Useful interfaces and easy operations of place enhanced blog allows trial users to create many blog entries as a spatial content on the blog in a short time, after only a simple short lecture for using our system. Flexible and simple privacy setting for personal spatial content is important to treat personal location information and spatial content on LBS. Our proposed location privacy functions may enable users to keep location privacy in their daily lives.

It is not enough that only one commercial LBS contains all personal spatial information. Therefore, it is important to

integrate between laPLCm and commercial LBS. For instance, when a user walks around Akihabara downtown in Tokyo, this system retrieves user's to-buy list in personal records and related shops' information on the commercial services, then this information is displayed on his/her mobile device synchronized with places of the users. Pushing users' past blog entries to each user can make them remember past forgotten memories and clarify their present situation from the life-span viewpoint. We have proposed a place enhanced blog for laPLCm in this paper. LBS are generally developed on the commercial telecommunication network services, and are usually not open in technical and use senses. Our proposal of place enhanced blogs is open on the platform of the Internet. Individuals can create and modify their own services by themselves using Web browsers and special software on mobile phones.

Easy manual self-positioning methods of both choosing routes of sidewalk networks and controlling walking mode such as walking, stopping, returning and running are significant to keep the location privacy for positioning methods. GPS and other positioning sensors can be also used with the manual positioning methods, but they are used in the pull style, not in the push style to allow users to be aware of the location of ourselves recorded by global positioning providers.

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