PlaceSense: A Tool for Sensing Communities

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Abstract

One challenge in the context-aware environment is to detect users' presence in a natural way and to process such information in order to provide suitable services for users. This paper introduces PlaceSense, an application using bluetooth technology, building on top of the Place-based Virtual Community architecture that can detect users presence for triggering services automatically. The paper also discusses the different use-cases of bluetooth technology for community sensing.

1 Introduction

Recently, more and more computers embedded in the environment have changed people's way of communicating and lifestyles. This shows that Weiser's vision about ubiquitous computing, now called pervasive computing is coming true when "the most profound technologies are those that disappear" and they "weave themselves into the fabric of everyday life until they are indistinguishable from it" [14]. Moreover, computers are not only embedded in the environment, but also carried by people. The small but powerful mobile devices that equipped with short-range wireless connection are become popular and affordable for many people.

The most common scenario for pervasive computing is people who are living in context-aware environments provided with suitable services based on their context. However, how to detect users' presence naturally and how to provide suitable services for users are challenges faced by many researchers.

There are many research projects using different technologies to detect users' presence in the context-aware environment such as using iButtons[1] in Context Toolkit [12]or RFID [13]. However these approaches have limitation in deploying to public places because of the users' adaptation and users' privacy. It would be not very comfortable if people have to issue their identity by any means when they want to go a public places. In addition, there is privacy concerns of using RFID to detect users because the RFID tags can be secretly tracked and the threat grows when RFID tags is associated with personal information [5].

This paper introduces another technique for detecting users' presence using Bluetooth, the technology that is already pervasive in the consumer market. The technique will be implemented under the PlaceSense application. The PlaceSense can be run in two modes which are (i) member detection mode for providing best services for an individual member of the community and (ii) anonymity mode for statistics and planing purposes. Our contributions are:

- A tool for detecting users' presence: the users' presence can become an actor that triggers many services automatically.
- PlaceSense can also be used for anonymously counting the number of people present which can be useful for service providers to do their planning before deploying a new service in a specific place.
- PlaceSense can also be applied for searching and rescuing in small and visually limited urban environments.

In section 2, we describe the experiments to illustrate the problems. The solution is presented in section 3 via the PlaceSense application. The evaluation and discussion about the interesting results and the privacy issues are presented in section 4. The future works and conclusion are in section 5 and 6 respectively

2 The experiments

For illustration, we describe two experiments with PlaceSense which are room usage monitoring and community patterns sensing.

[1] http://www.maxim-ic.com/products/ibutton/

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The first experiment focuses on detecting bluetooth devices in a seminar room in order to discover the usage pattern of the room.

The second experiment aims to discover the common gathering places of the members of a community. The community in this experiment is a Place-based Virtual Community (PBVC) [10]. This PBVC is a virtual community that appears not only online but also in the real life with specific members at specific places. This will be discussed more in section 3.2.

3 PlaceSense

3.1 Technology

The key technology for PlaceSense is Bluetooth on J2ME[2] enabled mobile phone. The Bluetooth is a short-range radio communication technology was firstly intended to replace the cables connecting between portable or fixed devices in a secure way. The key features of Bluetooth technology are robustness, low power consumption, and cheap. During a decade, from 1998 to 2008, nearly 2 billion Bluetooth products have been shipped [1].

The beauty of Bluetooth is it has a unique ID that can be assigned with friendly name and the ability to detect, to communicate other Bluetooth devices within a short range. Each Bluetooth device automatically creates its own "visible" zone and any other Bluetooth devices appear on that zone will be detected if they turn on the visible mode.

In addition, the Push Registry in MIDP[3] is an advanced feature that can help launching an application on the mobile automatically via incoming message to a specific port. We make use of this feature for triggering the application automatically. When the user is detected in different places, they can receive different messages based on their current place

3.2 Architecture

The PlaceSense architecture was built on the Place-based Virtual Community (PBVC) architecture [10]. PlaceSense is divided into 3 levels: the lowest level is the tags level, the middle level is the sensor level and the top level is the PBVC agent architecture (Figure 1).

In the tags level, each object was attached with a Bluetooth tag. The tags are bluetooth-enabled mobile phones or commercial bluetooth tags [4] to the objects in the environment. The tag contains its Bluetooth MAC address and the friendly name. Each tag has information in the system knowledge-base. In this prototype, we use the Bluetooth enabled mobile phones to represent a tag.

The sensor level includes mobile phones or computers which have the ability to scan to detect other Bluetooth devices nearby.

The top level is the PBVC which is a multi-agent architecture built on top of the JADE platform [2]. Members in the PBVC are not isolated from place. They have online identities but they also appear in the real life. The PBVC contains different types of agents such as the PBVC Agent, the Services Agent, the Place Agent or the User Proxy Agent. The PBVC Agent acts like a concierge at a hotel. It knows the community and uses the community knowledge-base. The services agent is a kind of agent who takes care of services in a community. The Place Agent is an agent based on user current location; it returns meaningful place information.

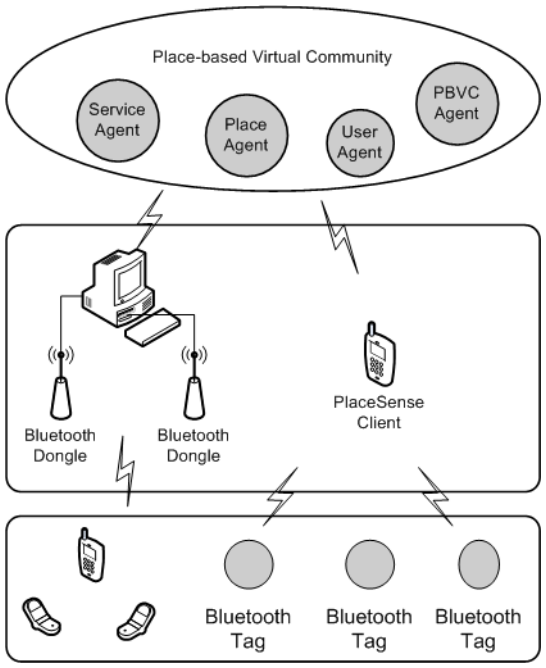

Figure 1. Architecture

3.3 Usage scenario

The aim of the PlaceSense is sensing the environment for Bluetooth devices, which are represent for users' presence. We deployed PlaceSense in two different modes, the static mode and the mobile mode.

In the static mode, there is a computer scanning for Bluetooth devices in every 5 minutes at specific places. If members of the community are there, they

[2] http://java.sun.com/javame
[3] http://java.sun.com/products/midp
[4] http://www.bluelon.com

will be notified or report to the system to get served. In the experiments, the system automatic send a message via Bluetooth to users' mobile phone to automatically start the greeting application whenever they step into the place belong to a PBVC.

In the mobile mode, the PlaceSense midlet is installed on the members' phones. They can recognize each other from a distance and know each others' presence via Bluetooth.

4 Evaluation and discussion

We continuously tested the program for 3 months in different places and discover many interesting observations from the experimental results.[5]

4.1 Room utilization

In the first experiment we monitored the seminar room and logged data to discover when the room is most crowded. Figure 2 shows the seminar room usage. The number appears on the diagram is the rounded average number within 3 months. We continuously monitored the faculty seminar room for 3 months in the second semester and found that the room was more crowded in the afternoon and increased from Monday to reach the peak on Thursday. There was an exception for Monday afternoon which are also detected, because the faculty staff meeting was scheduled at 1pm fortnightly. Usually, the real number of people in the seminar room are greater than or equal to the scanned results because not all people turned on their Bluetooths. But if we detect only one Bluetooth device in the room, we usually figured out that there may be more than one person in there because the purpose of the room is for seminar or doing video conferencing.

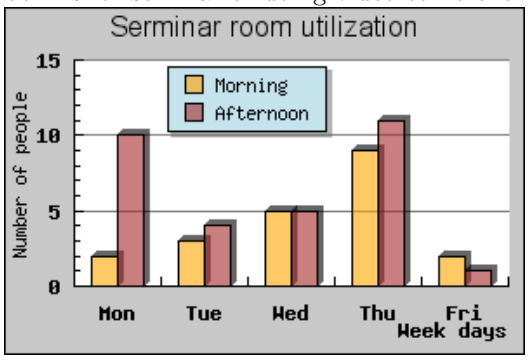

Figure 2. Room utilization

[5]For protecting the privacy and maintaining the anonymity, the places and ID are masked as much as possible but the experiment results and the analysis are based on real collected data

4.2 Community Patterns

In the second experiment, we observed the community of a group of postgraduate students which had a priori registered to form a PBVC. We found that they usually go shopping at the same market near to the university every Friday afternoon. With PlaceSense, we also experienced the familiar strangers phenomenon as described in [11]. The familiar strangers phenomenon was first described in [8], they are individuals that we regularly observe but do not interact with. According to Paulos et al., by definition a Familiar Stranger must be observed, encountered repeatedly, and has no interaction. By following this line of research, we found some interesting results. We discover that we encounter the same people and devices every time we visit the shop (i.e., not only familiar strangers but familiar "stranger objects"). In our system, to discover the familiar strangers, whenever visiting a place, we turn on the PlaceSense to detect bluetooth objects then save its information with timestamp and place at the moment it was detected to database. On the next re-visit a place when an object is detected, we compare with the database to see if it exists we mark them as a familiar stranger and increase the encounter time field by 1. By looking at this phenomenon in the reverse way, we can figure out the place where we are if we found these people or these devices. This would be interesting in the case that, in the visually limited environment, we can use things that PlaceSense detected to identify the place we are in.

For members within the PBVC, the place where members of the community meet each other is not only online but also in real life. Because we cannot always be online in a virtual place, we have to have actual social contact and interact with others in the place we live. We know that we will meet each other someday at some places.

Figure 3 shows a snapshot of collected data. The data is structured into four fields which are separated by commas. The first field is the timestamp (returns the number of milliseconds since January 1, 1970, 00:00:00 GMT), the second field is Bluetooth MAC address, the third field is the Bluetooth Name and the last field is the duration of scanning process to detect that device. The last field is for evaluation and performance purposes.

```
Date: Mon Oct 20 15:11:36 GMT+10:00 2008
T:1224479469146,0011xxyyzztt,Nokia N73,D:363
T:1224479483295,0022xxyyzztt,Nokia n95,D:14512
```

Figure 3. Snapshot of collected data

The Place is manually input by the users. At first,

we intend to detect places by using Global Positioning System (GPS), but most of the experiments are indoors or near buildings which are not suitable for GPS. As mentioned above, a place can be "understood" by examining the collected data. For examples, if the PlaceSense detected a bluetooth Kodak images printer that belongs to the Post Office, the user can figure out that he is close to the Post Office.

4.3. Interesting observations

During the experiments, we also discovered many other Bluetooth devices that were not "pre-known" by our system. After 3 months testing in the new places, our system collected 987 Bluetooth MAC addresses in four different places in Melbourne which are university campus, market, and two different train stations. There were some interesting results when we were processing the collected data.

The first result is the trend of mobile phone users turning on their Bluetooth devices in detectable mode. We also examine the way people name their phones. According to Kindberg et al. [7], the Bluetooth name can be categoried into four types which are identifier, association, graffiti and direct address. However we have discovered two mobile devices putting their favorite website's address for the Bluetooth name. This can be classified into another category for advertising purposes. Because the people who name their Bluetooth devices by URL are really concern that the URL be visited by other people.

The second result is the phenomenon that in a crowd, not only people but also their devices are presence. The devices came with people and went with people. In a coffee shop which has many customers presence. With the PlaceSense, we can "see" the "invisible" digital world over the real world. This phenomenon did not exist ten years ago. While RFID can be used in industry or manufacturing, the Bluetooth is perfect for urban usage because it is pervasive and easy to use for normal users.

4.4 Privacy issues

According to the Common Criteria,[6] there are four types of privacy which are anonymity, pseudonymity, unlinkability and unobservability. The Bluetooth technology opens a big issue of protecting users' privacy when a Bluetooth MAC address is unique, detectable and linkable to the real owners of the devices.

There is a study of exploring the Bluetooth landscape in the city of Bath that uses Bluetooth scanning for mapping and visualising digital flow [4] within the project Cityware.[7] Our application only scans and monitors members within registered with the community. Only members registered with the community are allowed to "see" each other.

In public places, we did the anonymous scanning, just counting the number of devices, places and time detected. We do not try to link to a real person based on their devices' names.

5 Related Work

Our research is closely related to the research of web presence for people, places and things project [6]. However, our system is based on virtual community presence. In that community, their will be more windows for people to see such as the multi agents view, the web view or the place view. For implementing the system, we need a method for detecting users' presence.

The early work in context aware computing is Context Toolkit which use iButtons to detect users' presence [12]. In the experiments, users have to dock their buttons in a reader to notify their presence. Because each button has a unique ID from which the system can get the user's identity. However, this is not convenience when applying for open urban area.

In addition [15], the authors use RFID technology for detecting user presence. The presence of the tag can trigger an action or issues of security and authentication [9]. However, RFID is not as pervasive as bluetooth in end-users market. RFID requires extra effort and investment in end-users. RFID also raises the privacy issues if people want to make a link between tag serial number and personal information [5].

6 Future Applications

Based on the results from the experiments we found that there are many applications that can be built using the idea of Bluetooth scanning. The Bluetooth scanning is a good solution for detecting user presence in applications that do not require fast detection speed. We believe that Bluetooth tags will come to predominate for many of the purposes we intend. For people living in urban areas, the Bluetooth-enabled mobile phone is the most essential device that they always carry. This gives rise to the people-centric sensing applications [3].

The first application we are building based on the idea of people within the community is the flocks tracking. The idea of this application is teachers take stu-

[6] http://www.commoncriteriaportal.org/thecc.html

[7] http://www.cityware.org.uk

dents to a tour. Teachers are equipped with PlaceSense and students are tagged with Bluetooth tags. The application will acknowledge to the teachers whenever a student is out of range.

The second application that can be useful is transportation planning. There is a need for public transport providers to know how many people are using trains everyday, when is the peak daily usages and where the congestion happens. With Bluetooth scanning, we can get those information for the system even though the percentage of discoverable Bluetooth devices to real number of pedestrians is low (ranging from 3.9% to 18.9% [4]).

Consequently, there is a need for a layer that processes collected data to build useful applications. We are building an ontology for the PBVC architecture that can support querying and reasoning about implicit information. At the current state, we are using the Friend Of A Friend (FOAF) ontology for managing members within the community. [8] Our multiagent architecture shown in Figure 1 serves this purpose, to process collected data using ontological reasoning. Future extensions of PlaceSense will explore the uses of this layer of reasoning context information to get more knowledge about the place.

7 Conclusion

In conclusion, detecting users' presence is a key requirement for building context-aware pervasive computing applications. In this paper, we have described the PlaceSense application, which makes use of Bluetooth technology for detecting users' presence in a natural way. With the representation of Place-based Virtual Community, we believe that the digital world super-imposed on the physical world as a community which is closely related can make deploying context-aware services more convenient. As part of our long term research plan, we are prototyping a Place-based Virtual Community ontology. Our goal is to create a framework for deploying a pervasive context-aware services for certain virtual communities in specific places.

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