Underground Positioning: Subway Information System using WiFi Location Technology

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***Abstract*—We introduce a subway information system which utilize WiFi location technology for supporting a person in the underground. The system is composed of a mobile terminal with a WiFi device and a communication server. We have developed seven location aware applications for the mobile terminal. Each of the application helps the user with current location information. We have performed a demonstration experiment in the subway of Nagoya City with 35 subjects and got a positive acceptance of the system.**

I. INTRODUCTION

WiFi location technologies become popular by the research papers[1,2] and several working services. Skyhook Wireless provides a service named "Loki"[3] and also serves for iPhone/iPod Touch WiFi location services. Koozyt also provides a WiFi Location Web services in Japan named "PlaceEngine"[4]. We have been also managing a portal page named "Locky.jp"[5,6] and gathers more than half million of AP location information for outdoor WiFi positioning. However, current working technologies are mostly for outdoors, because it is easy to gather the location of WiFi APs for outdoors using GPS and it is not easy to gather the indoor location of APs.

In this paper, we introduce a large-area indoor information system which utilizes WiFi location technology. We have developed seven mobile applications to support users of the Nagoya City subway system.

II. WIFI LOCATION DATABASE FOR UNDERGROUND

To implement a WiFi location system, we require a database for location of WiFi APs. Currently, there is no easy way to gather WiFi AP information for indoors. So we developed software named "Subway Stumbler". In this section, we introduce the software and the acquired database.

A. Subway Stumbler

It is not easy to gather the WiFi AP's location in the indoor environment. Usually, we have no mean to locate ourselves. So we have developed software to locate ourselves and to record WiFi environment. We utilize a digital photo of a floor map. In the most of the public places, we have a floor map sign board. But it is not easy to obtain the digital version of the map. So we decided to use just a photo of the board. By this decision, one can easily gather the location information using a PDA or PC which has a digital camera and a touch screen. Fig.1 shows a screen shot of Subway Stumbler. User can import a photo and zoom/unzoom for locating himself. Additionally, we are planning to use the software to upload the gathered AP location data to the portal server like Locky.jp.

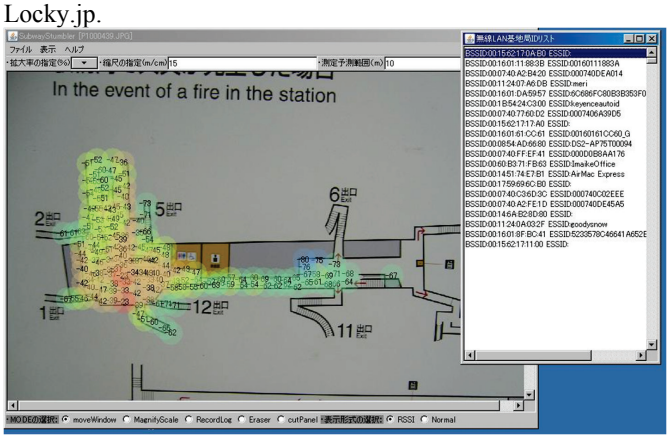

Fig. 1. Screen shot of the Subway Stumbler. Operator can point the map to record the current WiFi environment.

TABLE I
GATHERED WIFI AP LOCATIONS FOR NAGOYA UNDERGROUND

Number of Stations	83 stations
Number of Floors	356 floors
Number of APs	1,777 APs
Collected Points	28,620 points
Cost for gathering	30 man month

A. Gathered WiFi AP database

After the implementation of the Subway Stumbler, we started the AP information acquisition. We decide to gather the information of the WiFi in the stations of Nagoya Subway System because the subway just placed WiFi APs in 2007. Nagoya city is a large size city with two million citizens and have 6 subway lines with 83 stations. We map and gather the all floors of the all stations in Nagoya. Finally, we found APs shown in Table 1. We also transform the location of each APs from the relative position in the photo image into the absolute position in the WGS83 lon-lat. We put the all WiFi AP location on the Google Earth.(Fig. 2.).

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Fig. 2. Gathered WiFi AP location database for all 83 Nagoya Subway s

III. Mobile Location Aware Applications

We selected Apple's iPod Touch as the platform of the system because it has a WiFi, touch screen, large memory and good development environment. We have developed seven applications for Subway Information System on the iPod Touch such that:

- Launcher
- Nagoya Subway Rail Map,
- NextTrain (Real time timeable)
- Friend Map
- iNavi (Location aware database system)
- Underground Map.
- Station Map

Each application can start from the "Launcher" by using URL scheme with location information. Rail Map shows a real time status of trains from timetables.(Fig.3) NextTrain count down a time to next train and FriendMap shows a location of your friend using location server.(Fig.4) FriendMap has a function to chat with other friends.

Fig. 3. Launcher (Left) and Nagoya Subway Rail Map(Right) Application

Fig. 4. NextTrain(Real time timetable), and FriendMap (Right)

iNavi contains 40 thousand location related shop information. Station Map and Underground Map contains digital map of each places(Fig.5).

Fig. 5. iNavi(Left), Station Map(Center) , UndergroundMap (Right)

IV. Demonstration Experiment

By using these applications and iPod Touch, we have performed a demonstration experiment with 35 subjects. We made a group of a few subjects and give a different "task" for each. The task includes to find a shop, restaurant and to meet each other in the subway by using Friend Map. After the experiment, we collected equate from each subject about what they feel in the experiment. We got positive responses from most of subjects while there are future improving points.

Fig. 6. Subjects of the experiment in the subway station

V. Conclusion

In this paper, we introduce our implementation of Subway Information System. We have recorded all user logs of each subject. We can extract the intent of each subject with the location. So we will analyse the log to make a better recommendation of the service.

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