User Location Determination Using Wireless AP Access Information

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Abstract

User location is one of the important factors to provide user-customized services. For user location determination, various methods can be used including GPS, mobile network, NFC and QR code. GPS and mobile network has a difficulty to apply them in inner spaces and a error on location determination. And, since a tag needs to be close to a reader device, NFC and QR code require relatively longer time for tag recognition, causing user inconvenience such as recognition error. This study suggests a user location recognition method using the access information of the wireless AP in a certain space, to which users' smart devices connect. This method is based on the fact that smart devices connected to a wireless AP are close to this wireless AP since its service area is narrow. This method cannot be applied to provide one-to-one user-customized services. However, it can be used to provide communal services for users in a certain space. We suggest an electronic attendance system as one of the applications using the suggested method, and furthermore, a structure and service procedure of the system.

Keywords: *user location determination*, Wireless AP, *user location recognition method, access information, electronic attendance system*

1. Introduction

With the spread of smart devices, various services have been developed and come into wide use. In particular, a user-customized service, which recognizes users' circumstances based on their location, is one of the important smart services. This kind of services requires the location information of smart device users.

User location information is determined using either a GPS sensor in smart devices or the location of a neighboring mobile network base station. GPS (Global Positioning System) determines the location of a GPS receiver through microwave signals generated from more than 24 satellites [1]. GPS-based location determination, which necessarily requires the reception of signals from satellites, cannot be used in inner or underground spaces where signal reception from satellites is poor or not. There is also a location recognition method using a mobile network base station [2]. This method can be used in most smart devices available to connect with a base station. However, the error of location recognition is relatively greater due to the distance between the base station and user devices. Therefore, if users are in a little space, it may be difficult to have a accurate location recognition. In this way, if users are in a building or a underground space, the user location recognition through the GPS or mobile network base stations cannot provide the location information at above a certain level of accuracy, resulting in a failure in providing users location-based services. To resolve this problem, many user location detecting methods using smart video surveillance [3], fingerprint recognition [4], QR code [5], and NFC tag [6] are developed.

The smart video surveillance method recognizes users' face by capturing images of people, who go in and out of a space, through an image capture device at the entrance, and performing an image processing, resulting in a capability to determine whether a user accesses a certain space. Although this method has a relatively high accuracy of user recognition due to the development of image processing techniques, there is a limit that users' facial image should be registered in advance. Also, the accuracy of user recognition

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can vary according to the image processing and face identification methods. The fingerprint recognition method carries out user recognition by installing a fingerprint reading equipment at an entrance of a certain space and making space users put their finger on the equipment. This method has an advantage of controlling user access to a certain space. However, it also has some problems such as recognition error and increase of standby time during the reading in conditions, like conference halls or lecture rooms, in which many people access at the same time. The QR code method carries out a user recognition by installing a QR code reader device at an entrance of a certain space and scanning the QR code which is previously provided for each user. The NFC tagging method is similar with the QR code method, which makes users put their previously provided NFC tag on an NFC tag reader device at an entrance of a certain space. Since Korea's smartphone penetration rate reaches almost 100 percent, the user recognition in a certain space using a QR code and an NFC tag does not have any technical barriers as does the fingerprint recognition method. However, as described above, this method has some problems such as recognition error and increase of standby time during the reading in conditions in which many people access at the same time. Additionally, the entrance of users to a certain space can be recognized using their fingerprint, QR code or NFC tag. However, if users arbitrarily go out of the space, it is difficult to determine if the users remain in such space.

This study takes advantage of a high smart device penetration rate and a wireless communication device installed in smart devices, and suggests a method to determine the presence of users in a certain space through wireless AP access information. The suggested method in this study is to connect to a wireless AP installed in a certain space of smart devices having wireless communication functions (e.g. smartphones), access a user recognition system through this wireless AP, and exchange the information, so that the presence of users in a certain space can be determined.

2. Recognition of user presence using wireless AP access information

2.1. The recognition methods of user presence using AP access information

A wireless communication device is installed in most smart devices, diversifying the purpose of these devices. Based on this, many different services have been developed and provided. To access a wireless internet network (e.g. a WiFi network) for use of wireless communication services, users connect their smart devices to a wireless communication AP (Access Point), which is installed nearby and in operation, and then, they use a variety of services. Since the service area (coverage) of a wireless communication AP is narrow, ranging from about 10m to 40m depending on various environmental factors such as a propagation environment, a type of obstacles, an internal structure of buildings and materials of buildings, users who want to use a wireless internet service should be within the service area of the AP.

Based on the fact that users, who want to use a wireless communication service, should be near a wireless AP due to its service area is relatively narrow, the present study suggests a method to determine the location of users through the wireless AP access information. Figure 1 illustrates the method suggested in this study. It is assumed that a user having a smart device enters a certain space. The smart device of this user - specifically, an application program implementing the idea of this study and a service executing on smart devices (hereinafter "smart device") - goes through a wireless connection procedure with a wireless AP in operation in the space where the user is located, as shown in "1" of figure 1. If the smart device and the wireless AP is connected through this procedure, the smart device provides user identification information to a service activation server via the connected wireless AP, as described in "2" of figure 1.

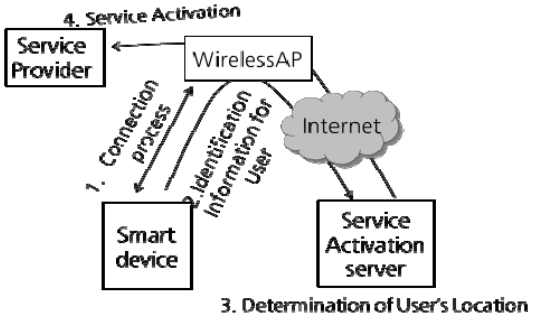

Figure 1 . Determination of users location by using information about wireless AP connection

The identification information includes phone number and MAC address information of devices, which is used to provide location-based user-customized services. Since the location of a wireless AP in a certain space is already known and the user identification information is transmitted via this wireless AP, the service activation server, which receives the user identification information, can determine the user location. As shown in "4" of figure 1, the service activation server, which recognizes the user location, transmits a service activation signal to the service providing device whose coverage includes the space where the user is located, and then, this service providing device gives to users the relevant services. In this regard, the service providing device communicates with the service activation server through the connection to the wireless AP or an extra network.

As described before, the coverage of a wireless AP service is relatively narrow, but there is a possibility to have multiple users in a space at the same time. Therefore, the method suggested in this study is expected to have a difficulty to provide a one-to-one customized service for users within the service coverage. However, it is possible to provide a communal service for them. For example, if the suggested method is applied to a small-scaled conference hall, it will become possible to provide conference-related contents for users in the conference hall and to identify the users attending the conference. When these users move to other conference halls, that is to say other spaces, they can receive the contents and services provided in such spaces.

2.2. Considerations for implementation

This section addresses considerations for providing user-customized services after the user location is determined using the wireless AP access information suggested in this study. A wireless AP goes through a wireless connection procedure to a smart device in accordance with a standard protocol, which requires setting up a password for wireless connection. This is to prevent users, who do not present in a space, from connecting a wireless AP, and consequently, receiving undesirable or wrong services when the coverage of the wireless service is wider than the size of the space. Additionally, a wireless AP should retain a dynamic allocation function for IP address to the connected smart devices, and a port forwarding function to transmit a message to a certain wireless client, based on a port number. If the number of users in a certain space exceeds the maximum wireless connections for a wireless AP service, multiple wireless APs can be installed and operated in such a space.

The information about wireless APs of each space should be registered in a service activation server in advance. A minimum wireless AP information required to be registered includes a installation place of a wireless AP and an IP address of a wireless AP. Also, services which can be activated via each wireless AP should be registered in a service activation server. this service activation server can identify a wireless AP via packets transmitted from users' smart devices. The services available to provide are determined using the identified wireless AP, and then, the information that activates these services is transmitted to a relevant wireless AP.

A service providing device is connected to a wireless AP whose coverage is the space where this device is installed. This service is activated via a port number registered in a service activation server. Therefore, even if more than one services are provided in a space, the allocation of different port numbers for each service can facilitate providing services depending on the conditions such as time or the number of users.

Smart devices, which are portable devices of users, have to have a function to use a network service through the connection to a wireless AP, and a capability to run an application program for the method

suggested in this study. An application program searches a wireless AP near a smart device and connects to a wireless AP working in a certain space. Thereby, the user information is transmitted to a service activation server. If users are in the building with many different spaces, their smart device can search multiple wireless APs. A wireless AP required to be connected to smart devices should be determined in the light of the user context that is the user neighboring circumstances and situations. This user context can vary according to the application field.

3. An example of an application: Electronic attendance-absence recording systems

Electronic Student attendance-absence recording systems are the typical location-based service which determines student attendance at lectures. Many universities in Korea install and run these systems to strictly and effectively determine the student attendance at lectures and to improve the objectivity of attendance results. These systems verify the attendance or absence of students by exposing a REID tag or QR code of students to a REID tag or QR code reader installed at a gate of lecture rooms. However, this method has many problems, such as recognition error, proxy attendance and errors of the system itself, which tend to be more serious at large lectures [7, 8]. Also, the electronic student attendance-absence recording systems based on the location recognition of a GPS function in students' smart' devices have many problems including a location recognition error, causing an ineffective use of these system. To resolve these problems, system development companies strive to find ways to accurately recognize the location of students [9].

An application of a recognition method for user presence in a certain space through the wireless AP access information, which is suggested in this study, can be applied in these electronic attendance systems. Figure 2 illustrates the architecture of electronic student attendance-absence recording systems which verify the presence of students in lecture rooms as suggested in the present study. The operation procedure of these system in figure 2 is as follows: A client application program of an electronic attendance system, which is installed in students' smart devices, transmits the students' context, such as time and identification information, to an electronic attendance server. A network used for the information transmission includes a mobile network of smart devices and a wireless sharing network. The network address required to access an electronic attendance server is known in advance. The electronic attendance server, which received the student's context from their smart devices, is installed in order to use lecture room information and run the electronic attendance system, based on students' lecture information, and then, transmits wireless AP-related information to the smart devices. After receiving the wireless AP information from the electronic attendance server, these smart devices perform a procedure for a wireless connection to the wireless AP. Since the coverage of wireless APs are narrow as discussed before, smart devices of students in a lecture room within the coverage of a wireless AP can be normally connected to this wireless AP. However, if students are not in the coverage of a wireless AP, even though their smart devices receive wireless AP information from an electronic attendance server, these devices cannot access a relevant wireless AP.

If smart devices are normally connected to a wireless AP, the user identification information for students are transmitted to an electronic attendance server through the network connection via this wireless AP. Based on this information, a server verifies the student presence in the coverage of a wireless AP to which the location information is registered in advance and transmits the relevant information to a student attendance recording service. Based on the student attendance-related information from the server, this student attendance recording service provides the student attendance-related services such as real-time confirmation of attendance history.

4. Conclusion

One of the most important user contexts to provide user-customized services in the light of their different situations and circumstances is the location of users. Even if a service is the same, its contents provided for actual users should vary according to the current location of users. With the generalization of smart devices, user location-based services have been actively developed and offered. To provide a location-based, user-customized service, a system has to recognize the location of users. The representative methods to recognize a user location are to use a GPS and a mobile network base station.

The GPS method cannot be applied in an environment, in which satellite signals are weak or cannot be received, such as buildings and underground. The method using a mobile network base station also reveals

a significant level of errors, resulting in a difficulty to provide user-customized services at an appropriate level.

The present study suggested a method to determine the location of users through the wireless AP access information of their smart devices. Since the location of installed wireless APs are known in advance or can be known, the location of smart devices connected to a wireless AP is considered to be in the coverage of the installed wireless AP. Therefore, it is possible to provide a communal service for users in the coverage of a wireless AP, via their smart devices connected to this wireless AP. An electronic student attendance-absence recording system was also proposed as an application system that uses the recognition method for user location which was suggested in this study.

Further researches need to develop methods for a more accurately identification of user location via multiple wireless APs, and relevant system structures as well.

5. References

[1] GPS, https://en.wikipedia.org/wiki/GPS
[2] Shim Dong-Hee, "Mobile Location Service", *TTA Journal : IT Standard & Test*, No. 110, pp. 93-98, Telecommunications Technology Association, Mar. 2007
[3] Z. Liyan, K. Dmitri, M. Sharad, and V. Ronen, "Context-based person identification framework for smart video surveillance", *Machine Vision & Applications*, Vol. 25, Issue 7, pp. 1711-1725, Oct. 2014.
[4] Fingerprint Recognition, https://en.wikipedia.org/wiki/Fingerprint_recognition
[5] Kang Min-Seok, Lee Jae-Seong, "Complementary indoor positioning algorithm using triangulation of Bluetooth beacon and QR-code positioning", Proceedings of Symposium of the Korean Institute of Communications and Information Sciences, June 2015, pp. 1562-1563.
[6] B. Park, J. Jang, C. Lee, and G. Li, "An Empirical Study on Marketing of NFC and LBS in Public Performance", *Journal of Korea Safety Management & Science*, Vol. 17, Issue 1, pp. 301-308, March 2015.
[7] Korea University Nuew : campus life, "Student's dissatisfaction about Electronic Attendance System is building up", Sep. 16. 2013.
[8] Ha Do-Young, "For Whom the Electronic Student Attendance System is? Students experience inconvenience", OhmyNews, June 15. 2015.
[9] Sejong University, "iOT, Electronic Attendance-Absence System based on Location", 2015 Spring Conference, The Korea National Association of University Information Technology Directors April 2015.