Analysis of Multi-rate Wi-Fi Signals for FingerPrint Indoor Positioning

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Abstract: The FingerPrint positioning method is known as a superior method in indoor positioning system that maintains previous signal strength patterns and compares with the measured new real-time signals on APs. In this paper, we analyze active signal phenomena using multi-rate Wi-Fi signals from reference AP which is accessed by multi-users. Some important factors which can effect to the accuracy by comparison among previous signal patterns in the DB and real-time active signals are studied. Some interesting phenomena based on AP connection and disconnection signals are observed.

Keywords: Indoor positioning system, FingerPrint, WI-Fi AP, real-time active signal, signals pattern comparison

1. Introduction

Global positioning using satellites is the common outdoor positioning system. But the Global Positioning System (GPS) can't be used in indoor environments[1]. So another method for indoor positioning system is needed. WLAN shows good performance in terms of feasibility, infrastructure, implementation of positioning technology and IPR (Intellectual Property Right)[2,3].

Wi-Fi is the most common infrastructure in WLAN. Because of Multi-Path of a signal source and interference among signals, there is an irregular signal attenuation phenomenon in indoor wireless environments. The signal sent from an AP (Access Point) is propagated through the multiple path with different distance, so that irregular RSSI (Received Signal Strength Indication) values may be measured at the same place[4,5].

2. Relatd reserch

The FingerPrint positioning method based on RSSI is used as a common method in indoor positioning system; it stores the previous signal pattern of each RP (Reference Point) from APs in the DB (Data Base) to compare that pattern with new, real-time signals.

2.1. Signal strength in FingerPrint Positioning

The received signal strength pattern at each RP (Reference Point) from APs is stored in the FingerPrint DB. Figure 1 shows the concept of FingerPrint DB[2, 7, 9]. Each AP is a Wi-Fi access point in WLAN and an RP is a reference position for calculation the position in the work area.

Figure 1. An environment of FingerPrint real-time positioning

In figure 1, AP1, AP2, AP3 and AP4 are Wi-Fi access points for signal sources. The positioning area is divided into a grid and each square works as a reference point (RP). The mobile device collects the signal pattern measured in real-time from APs and sends it to the server, and the pattern is compared with the FingerPrint DB by using similarity function to assume the location of the mobile device[6].

2.2. IEEE 802.11g Multi-rate transmission

AP uses various modulations provided by 802.11a/b/g/n after checking among the clients' RF (Radio Frequency) condition. For example, when a frame is transmitted between AP and user X by 54Mbps Modulation, and the sensitivity of restored frame is less than -65dBm, the receiver

may fail to have correct signal, then sender does a few more tries. If the tries fail repeatedly, the sender chooses a lower rate, for example, 48Mbps modulation.

3. Analysis indoor Wi-Fi signals

The most important thing is to ensure the accuracy of FingerPrint DB according to the principles of 2.1. The characteristic of the momentary received signal strength in FingerPrint training phase and the real-time measuring method for positioning are important. The RSSI values measured by the mobile device are considered as signal. Because of the change of environments there may be some errors in momentary measuring. Thus, there may be a moment that the received signal strength from AP changes dramatically[10,11].

3.1 An experimental environment

A mobile device which has Wi-Fi Inspector v1.2.0 program provided by Xirrus is used for signal inspection[8]. Wi-Fi Inspector v1.2.0 collects and shows the detailed information including RSSI of AP's searched around.

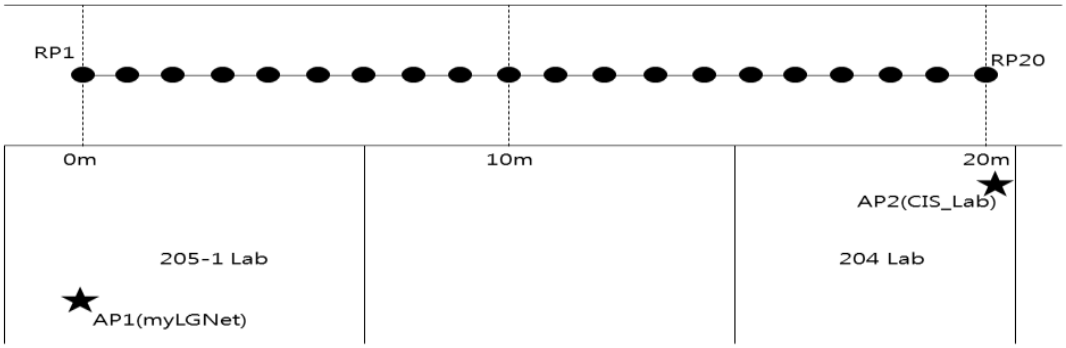
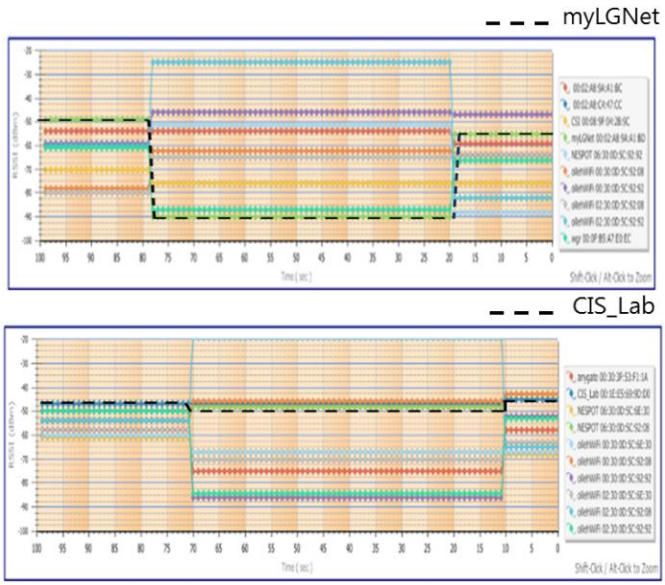


Figure 2. 20 reference points for analysis and experimental environments

In order to observe the received signal pattern, we consider three cases: with AP1 and AP2 disconnected, with AP1 connected and with only AP2 connected. We measured 100 times in 1 second intervals. Mobile device can receive signals from 8 additional APs scattered around the experimental area.

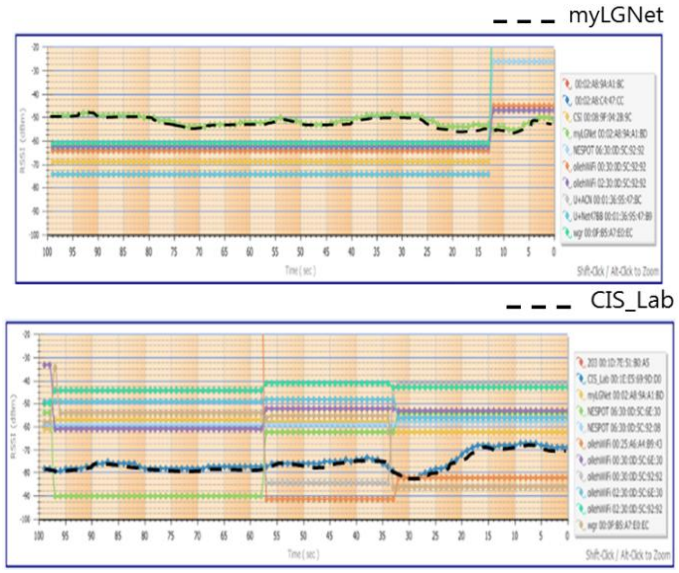
3.2 Received signals strength based on disconnection of states

Figure 3-a indicates the difference of received signal strength from each access point (AP) over time at each reference point (RP). Figure 3-b shows difference of signals based on AP connection and disconnection.



(a-1) At RP1 (a-2) At RP19

a. Received signal strength from Aps based on disconnected Aps



(b-1) At RP1(Connected With AP1) (b-2) At RP5(Connected With AP2)

b. The received signals strength from APs based on AP1 connection

Figure 3. Received signal strength

The following elements may give some impact to the RSSI signals according to the phenomena found in figure 3-b.

(1) There are some changes in the receiving signals at some RPs according to the AP connection state.

(2) The received signal strength on connection state to an RP is more stable than that on a disconnection state though the signal propagation environment is changed.

3.3 Effects of multi-rate signals

The patterns discovered in figure 3-a can be explained according to the process of Wi-Fi communications. The mobile device and the AP exchange the information of the supported rates and extended supported rates using supported rates field and Ext. supported rates field in the phase of reassociation of request/response. The AP sends the data to the mobile device with the rate supported by the mobile device. If data can not be transmitted smoothly, the AP will send the data again using lower level rate supported by the mobile device. The process is repeated, so that the signal strength which the mobile device receives can be varied based on the characteristics of Multi-rates.

3.4 A suggestion for increasing positioning accuracy on FingerPrint DB

To increase the accuracy of FingerPrint DB based indoor positioning, the signal strengths of connection based and disconnection based must be considered on preparing reference FingerPrint DB. All the added elements in DB must be compared on real-time positioning.

4. Conclusions

In this study, we found that strength of received signals based on access point (AP) connection is higher than that of AP disconnection through experiment. The connection and disconnection signal strength must be applied to indoor positioning based on FingerPrint DB for improving position accuracy. As further research, we have to study various analyses on various network configurations, calculation complexity and effects of actual implementation.

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