Enhanced Location Estimation in Wireless LAN environment using Hybrid method

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Abstract

Location Estimation in Wireless LAN (WLAN) environment become a importance part for network administrator to monitor the traffic within the network. 2.4Ghz 802.11(G/B) Wireless Router become more popular. Most of them can run an open-source firmware like dd-wrt, open-wrt in order to obtain useful information like Received Signal Strength (RSS) for positioning. Programmable firmware like open-wrt for Linksys WRT54G[2] is handy for us to store important Location Fingerprint (LF) and RF propagation loss model(PL) Location information into database, which helping network administrator to monitor the wireless network for surveillance purpose.

1 Introduction

Recent electronics, computer and wireless device become more in-expensive, low-power usage and multi-functional. Recent open-sourced router have fast data processor in order to do the best job in data retrieval for wireless network surveillance as well as wireless location estimation.

A programmable Linksys WRT54G burned with open-sourced custom-made firmware is act as a wireless sensor in order to obtain information from the wireless environment, Service Set Identifier (SSID), Extended Service Set Identifier (ESSID), Signal Strength (RSSI) and Noise Level. A custom-made wireless data-retrieval application is written for the WRT54G, a cross-compiled binary for 32-bit MIPS architecture processors manufactured by Broadcom is generating the best information to archieve our goals.

The RSSI information obtained from the AP is varying in a fixed position, due to interference, multi-path effect etc. However, according to the data collected from the AP, we find some hints on the effect of the interference which may helps estimating a position of the system.

2 Requirements

For Location Fingerprint (LF)[6], a server machine to store the database which hold the offline-phrase training data, time-stamp, ESSID and RSSI etc. A trained data is used to estimate the position for the on-line user.

Multiple Linksys WRT54G burned with a cross-compiled binary is used to store wireless information into database server.

A Online and Off-line trained data also act as a surveillance system to let the network administrator to monitor the network behavior.

Mobile Device which is WLAN enabled to obtain RSSI information from AP. Nokia N96 which running Symbian 3.2 is programmed to extract WLAN information. When the mobile device is associated to AP, both side can obtain a RSSI from each other.

RF propagation loss model(PL)[1] is used to calibrate and enhance the Location Fingerprint (RF) in the future works.

3 Positioning Technique

3.1 Location fingerprinting (LF)

Location fingerprinting method requires a training dataset, which is the collection of data (Fi, Li), i = 1, . .

. , N, for N locations in the site, where Li is the known location of the ith measurement and Fi = (Fi1, . . . , FiN) is the RSSI vector when the AP is at Ci. Fi is the fingerprint of the location Li. When a new fingerprint F is observed from AP with unknown location A, search the database fingerprint Fi that is closest to fingerprint, and so we can estimate fingerprint F and location L.

3.2 RF propagation Loss Model and calibration

A Free space path loss equation:
Lp(db)=20*LOG(f)+20*LOG(d)-function(fx)

d is distance in m
f is frequency in Mhz (i.e. about 2400 in 802.11 standard due to difference channel)
function(fx) is the signal loss function due to obstacles

Calibration for function(fx) is needed, some component and module manufacturers use this model to predict their operating range, but sure can no be see in the real world. Multi-path fading and interference, the real world is full of obstacles that absorb, reflect, and scatter RF energy, including the earth itself. Looking for these factors to attempt to create a better pat loss model to predict a real world Location Estimation. In addition to multi-path fading, ISM band radios are also subject to interference from other unlicensed radios, raising the noise floor in the transmission channel. If the noise floor is too high, the receiver effective and performance will be dropped.

4 Experiment

4.1 Experimental Testbed Preparation 1

Figure 1 shows our Experimental Test bed with obstacles in RRS 716, the experimental laboratory. The laboratory detected about 25 APs to demonstrates interferences. There are three AP obtains a signal Data, which is BUAP7, BUAP9 and BUMAIN, others are the mobile device. The number in the middle is the distance unit between the AP and the mobile device. For example, distance from BUAP7 to BUAP1 is 129 units. About 50000 Samples was taken for every mobile device. The Distance and the received RSSI is used to plot the graphic.

4.2 Experimental Testbed Preparation 2

Figure 2 shows our Experimental Test bed without obstacles in the corridor outside RRS716. The laboratory detected about 25 APs to demonstrates interferences, about 500 Samples was taken for more than 10 distances, distance unit marked has been taken a sample for analysis.

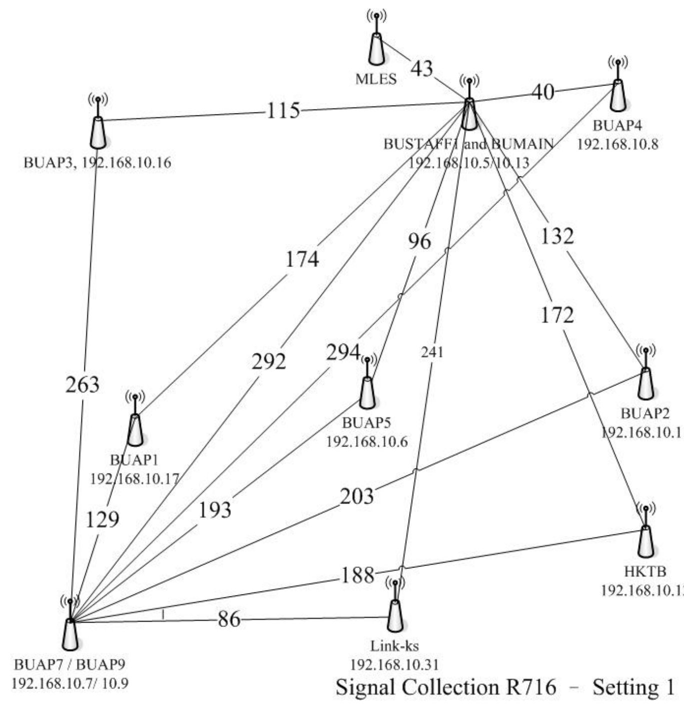

Figure 1. Testbed Preparation 1

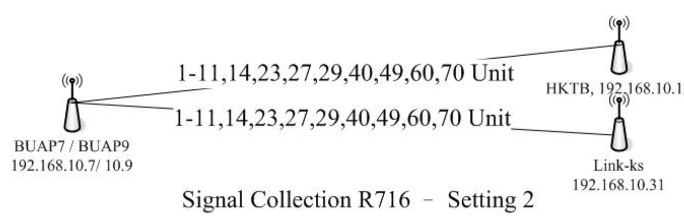

Figure 2. Testbed Preparation 2

4.3 Experimental Testbed Preparation 3

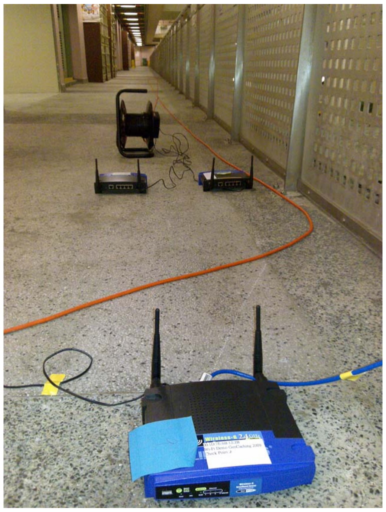

Figure 3. Testbed Preparation 3

Figure 3 shows our Experimental Test bed without obstacles in the outside environment, only 4 APs is detected, about 100 samples was taken for more than 10 distances, distance unit marked has been taken a sample for analysis.[5]

5 Test Result and Analysis

5.1 Result and analysis - Testbed 1

Samples was taken for BUAP1, we recorded -31,-33,-45 RSSI level most frequency. The distance between BUAP7 and BUAP1 is 129 Units(i.e. 10.75ft). Figure 4 and 5 shows the graph for RSSI level and its frequency, sorted by RSSI and its frequency.
In Figure 4, the result is sorted by RSSI, three peak is observable, RSSI -31 has most frequency of 11092, the second peak is -45, but the frequency is not higher then RSSI -33, and the third peak is -63. From the experiment, we can see the there are multi-path, construction interference and de-constructive interference may occur inside the test bed. This raise a importance information for the future works, as those peaks RSSI are evenly distritbuted within the spectrum, some computation can be made to identify the wireless environment(i.e. indoor environment / inside the crowded room).[3]

5.2 Result and analysis - Testbed 2

Samples taken for 11ft, which show highest frequency recorded for RSSI is -58. This test bed is used to computet

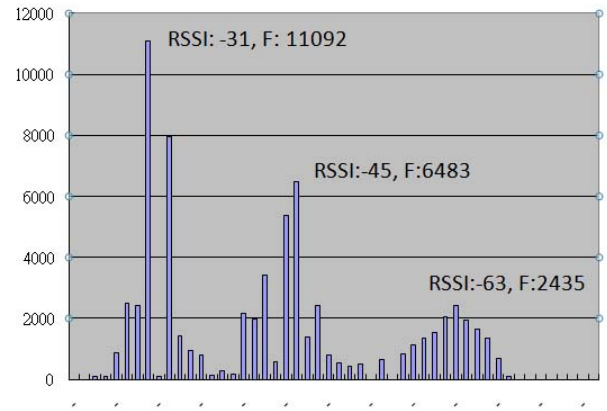

Figure 4. Testbed 1

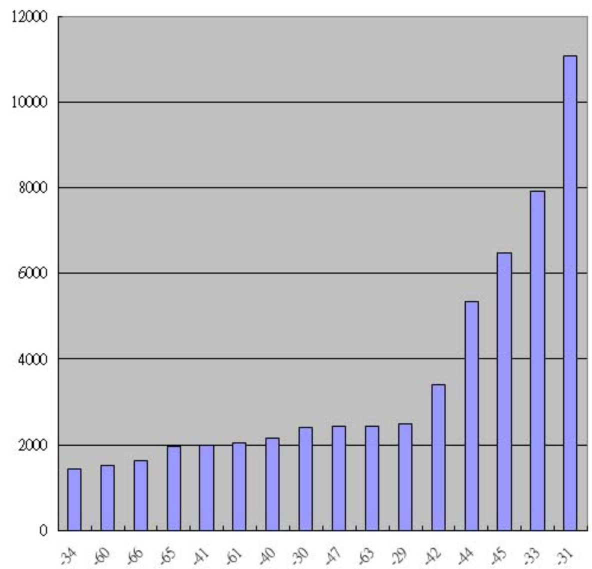

Figure 5. Testbed 1 Sorted

the function(fx) for the RF propagation Loss Model (PL). If we don't have the exact X,Y information of the AP, we can still estimate the distance between the AP, which act as a wireless surveillance monitor. In this situation, the function(fx) is

Lp(58)=20*LOG(2425)+20*LOG(3.3528)-function(fx)

i.e. function(fx)= 20.202

This function can calculate when we receiving average of RSSI -63, d=5.961m (19.55ft).

The median distance error slightly, from 1 m to 3 m.

The result is not going to be valid, for RSSI -63, the distance should around 27ft from my training data, this is the result why PL may not be accurate when using one AP for location estimation.

We should design how function(fx) work in dynamic environment in the future.

5.3 Result and analysis - Testbed 3

For outdoor environment, the PL demonstrate better performance, the RSSI spectrum is much narrow then indoor, the RSSI peak is obversely. For Figure 6, the average RSSI for 46ft, from -52 to -55, which is easier to identify, and less dynamic to the PL equation function(fx).

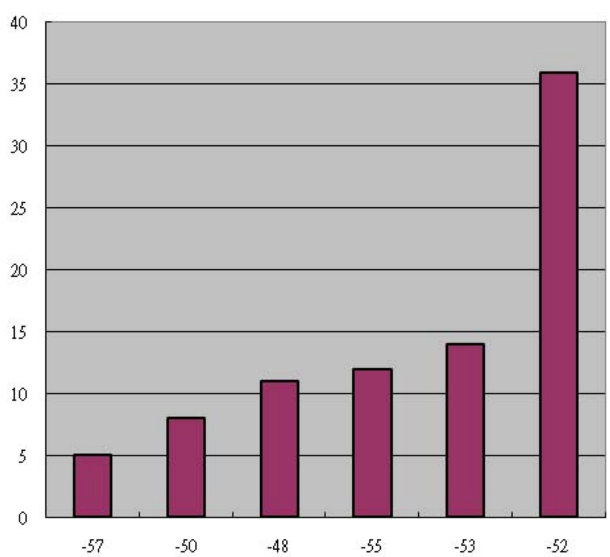

Figure 6. Testbed 3 Sorted

6 Experimental Result

In Testbed 1, there are 3 signal retrieval points, and total of 9 fixed mobile device, a total of 10 training points. The training process is placing the mobile device at a particular location, the AP is receiving RSSI and store into the database.

Referring to Figure 4, the RSSI spectrum spread across intensively from -27 to -34, -41 to -43 and -56 to 64. Three peaks are obtained from the result, the phenomenon is important to the future work, as it can be deviated and compute how the RSSI will look like in some indoor situation. For indoor situation, the RSSI spectrum is wide and fluctuated, on the other hand, for outdoor situation, RSSI spectrum is narrower and RSSI level is more stable. In order to made PL equation to be trustable, further study on the behavior of how the function(fx) varying is a must.

Multi-path fading and people's activities lead the RSSI fluctuated. According from the dataset collected from the fingerprint measurement, various signal statistical character is observed.

Figure 7, showing the multipath affecting the relationship with signal and distance. Multi-path will lead to the distance longer then the direct one and causes signal diminished. The distribution of the RSSI spectrum is varied by those kind of effects.

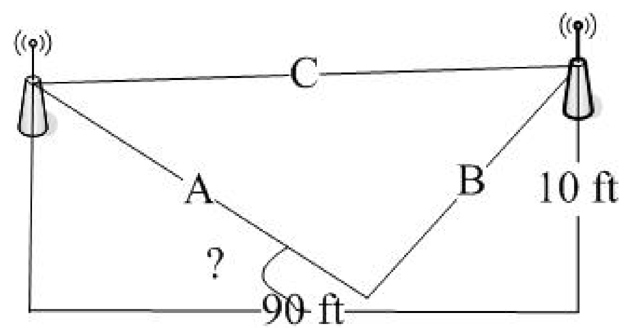

Figure 7. Multipath

7 Conclusion and future work

Enhance the WLAN Location technique by observing signal statistical character[4] has been introduced. By combining the technique with FP and PL, location estimation can be applied and evaluated. The future work is to expose more factor affecting the RSSI, combine the factor to enhance the location estimation.

Difference device and wireless electronic component release difference power of signal, a calibration system for the fingerprint is proposed to enhance the presence positioning method. Afterward, a wireless network surveillance monitoring system can be proposed.

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