

Lab 1: Signal Strength Lab

1. Overview

The wireless signal received by mobile terminals can be very dynamic. In this lab you will measure Wi-Fi signal strength using the Linux command and find out how it changes.

2. Requirements

- a) Teams of 2 students, using 2 devices
- b) We expect that doing the measurements should take about an hour. Writing the report should maybe take twice as much time.
- c) Deadline: Friday, July 22

3. Set up

The wireless signal received by mobile terminals depends strongly on the physical environment, i.e., distance, objects present, mobility, etc. In this lab, each team needs two computers with Linux OS. We are going to measure the signal strength using the Linux command *iwconfig*. *iwconfig* is a wireless tool that can be used to display and change the parameters of the network interface that are specific to the wireless operation. We use it in this lab to get the network information.

We have provided with a script called *signalTest.sh* that invokes *iwconfig* repeatedly with a certain frequency. By running this executable shell script, something like `Signal level=-65 dBm` will be printed in the screen. It means the Wi-Fi signal level for the last packet that was received is -65 dBm. You may use the method introduced to calculate the average of the Signal level in the experiments described below.

For more detail on *iwconfig* see:

<http://linux.die.net/man/8/iwconfig>

https://en.wikipedia.org/wiki/Wireless_tools_for_Linux#iwconfig

➤ Introduction of dBm:

dBm is an abbreviation for the power ratio in decibels (dB) of the measured power referenced to one milliwatt (mW). It is used in radio, microwave and fiber optic networks as a convenient measure of absolute power. The bigger it is, the stronger the signal is. See more details in:

<https://en.wikipedia.org/wiki/DBm>

<http://baike.baidu.com/item/dBm>

➤ Introduction of our measure method

iwconfig uses driver meta information to interpret the raw value given by `/proc/net/wireless` and display the proper unit or maximum value (using 8 bit arithmetic). The driver calculates the signal strength using the packets received from the AP. The value will not change until the arrival of next packets. For example, in Figure 1, there are three packets received from the AP at 0.1s, 0.3s and 0.5s respectively, and the signal strength measured by the driver is -30dBm, -50dBm and -40dBm respectively. If we use the *iwconfig* to measure the signal

strength every 0.1s, the result will be -30dbm, -30dbm, -50dbm, -50dbm, -40dbm.

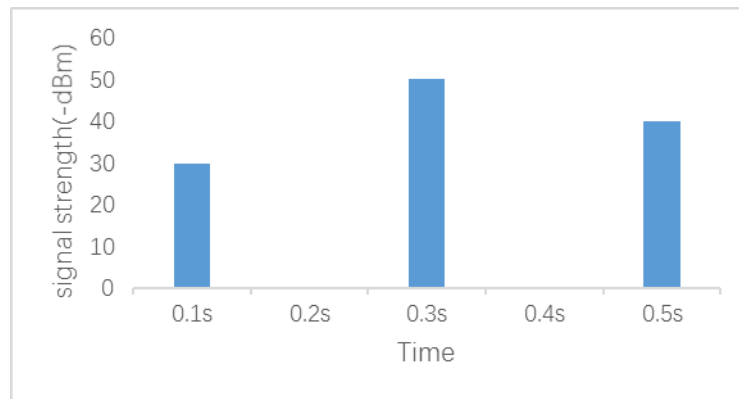


Figure 1: The packet receiving condition

We can clearly get more fine-grain information about the channel by receiving more frequently, so we use flood ping to continuously send packets and receive packets from the AP to make the driver update the signal strength more frequently. Since the ping flooding also takes some time, we should not use the test script with too short an interval.

➤ **Method to calculate the average of the signal level:**

To express an arbitrary power P in mW as x in dBm, the following equivalent expression may be used:

$$x = 10 \log_{10} \frac{P}{1mW}.$$

When presenting your results, you will sometimes have to average measurements, e.g., average the measurements x_1, x_2, x_3 in dBm. We cannot directly add them together. We have to translate them into power in mW, which we can then average. We can transmit them to power using the following expression:

$$p_i = 10^{\frac{x_i}{10}}, i = 1, 2, 3$$

Average them and get the result:

$$10 \log_{10} \frac{\sum p_i}{3}$$

4. Measure between two stationary device

Even when two devices are stationary, the signal strength may still changing over the time. Our goal is to measure how it changes.

Open your computer and type the following command to become root (super administrator).

```
$ sudo su
```

4.1. Turn one of the devices into a wireless Hotspot

You can use whether a cellphone or a computer to function as a wireless hotspot.

Here are some instructions that may help you. We strongly suggest you using the cellphone.

Because it is really not easy to do it on computer, especially in the Linux. Note that, the hotspot in mode ad-hoc cannot work in this project.

For Windows 7: <http://wenku.baidu.com/view/b18d7fd3195f312b3169a592.html>

For Linux: <https://github.com/prahladyeri/hotspotd>

4.2. Put the two devices in fixed place

You can put them where they can receive the wireless signal between each other. And make sure not to move them during the test. Take note of the distance between two devices.

4.3. do the test

Copy the file *signalTest.sh* into your workspace and type the following commands in the Linux command line.

Use the following command to get the AP' s gateway IP;

```
$ ifconfig
```

See the wlan0 filed and find the **inet addr** or **Bcast** ip, modify the number after the last point to 1.

For example, modify 162.15.31.255 to 162.15.31.1. The 162.15.31.1 is AP' s gateway IP.

Type the following command, and do not stop it until the test finished. (ctrl+C can stop it)

```
$ ping -f xx.xx.xx.1(AP' s gateway IP)
```

Open another terminal and became root:

```
$ sudo su
```

Run the script:

```
$ bash signalTest.sh
```

```
$ bash signalTest.sh>result1.txt
```

The first command will print the result to the screen so you can conveniently read it. The second command output the result into the file *result1.txt* which will be submitted later. Note that by running the script, the signal strength will be measured 10 times/s and 300 times in total. You can change the two parameter in the script *signalTest.sh* which contains the instruction. Write your changes and what you find in report. Note that the interval shouldn' t be less than 0.04s because the reason we mentioned in section 3.

Next, run the four experiments described below and analyze the results. For each experiment, your report should briefly describe how you collected the results (1-2 sentences), summarize the results (table or graph format; you can include summary statistics such as averages if you think this is useful), and briefly discuss the results considering what you learned in class (1-2 paragraph). Note that you should pick the format for how to present your results based on conclusions you want to draw. We list some specific suggestions for what to discuss for each experiment.

- a) Run the experiment in LOS conditions with low mobility. LOS is Line of Sight, i.e., a direct unobstructed path between the sender and the receiver. Low mobility means that there are few or no people moving around.

Suggestion: It would useful to plot the signal strength as it changes over time. How stable is it? How about if you average the measurements, e.g., over 1 second intervals? How does this result compare with sampling only once per second?

Feel free to run experiments with different frequencies if you think that helps.

- b) Run the experiment for a few different distances (for example: 5m, 10m, 20m, ... - distance does not have to be precise!).

Suggestion: How does signal strength change with distance? Is there a trend? Does it fit the discussion in class?

- c) Repeat the same experiment under a) for non-line of sight conditions, i.e., the two devices are separated by walls or doors, or are even in a different part of the building (e.g., different floors or corridors).

Suggestion: how do the results compare with those of a) and b)?

- d) Repeat the same experiment as in a) in a high mobile environment, i.e., in a crowded area where a lot of people are moving around and are crossing the LOS path between the two devices.

Suggestion: how do both signal strength change over time compared with a)?

5. Measure between a stationary device and a moving device

This experiment uses the same set up as in the previous section, but you will walk around with one of the devices while the experiment is running. You may have to increase the time that the script runs. The idea is that during the experiment, you move between different signal propagation environments (such as those covered in the experiments in the previous section) and you then see whether the received signal changes as expected. For example, you start close to the hotspot in a LOS scenario, you then walk away (increasing the distance), turn a corner (or break LOS in a different way), maybe take an elevator, etc. Be creative!

The report should briefly describe the experiment you did and what you learned. One possibility is to use a table (as shown below) and to annotate it, e.g., big drop in signal strength because of reason X, gradual increase in signal strength because of reason Y, increased variability because of Z, ...

Distance between two computers	Average Signal level(LOS)	Average Signal level(non-LOS)
0.5m		
1m		
2m		
4m		
6m		
10m		

6. Hand in

6.1. requirement

a) Take note of what version of Wi-Fi that is used

Get what version of Wi-Fi that is used by typing the following command:

```
$ iwconfig wlan0
```

It prints something like:

```
wlan0      IEEE 802.11bgn  ESSID:"Wireless PKU"  
          Mode:Managed  Frequency:2.462 GHz  Access Point: 00:3A:98:EA:83:70
```

```
Bit Rate=18 Mb/s   Tx-Power=20 dBm  
Retry long limit:7   RTS thr:off   Fragment thr:off  
Power Management:off  
Link Quality=34/70   Signal level=-76 dBm  
Rx invalid nwid:0   Rx invalid crypt:0   Rx invalid frag:0  
Tx excessive retries:0   Invalid misc:6   Missed beacon:0
```

Take note of the MAC protocol, Frequency, Tx-Power as the information of Wi-Fi.

To see more information about the *iwconfig*, type the following command:

```
$ man iwconfig
```

b) record your experiment

Record and analyze your experiment result.

c) answer the questions

- (1) Why is necessary to record all the measured value rather than only the average value in section 4? Please give your own explanation.
- (2) Besides the WiFi signal strength, what other information of the Routers can be got in the test?

5.2 submit the report and output files

Send to: jing.wang@pku.edu.cn

Please write down your contact information and team members in your report.