SOWN Project: Design your own antenna

Fall Semester, 2019

1   Introduction

In this project you are given the task of designing and building a 2.4GHz wireless network antenna. The antenna will be compatible with some of the 802.11 standards (however, not all), and should improve your signal reception and transmission. The goal of this project is that you become familiar with the design and implementation requirements of such an antenna. Your final report will reflect the design, implementation steps, measurements as well as the questions posed in this document.

2   Guidelines

The antenna design you choose to implement needs to be i) *directional* and ii) *high-gain*. Other than these two requirements, we give you the freedom of choosing which kind of antenna you build, as there are many designs for the 2.4GHz band (cantenna, parabolic, yagi, woktenna, etc.). By searching the Internet, you will find a multitude of different antenna designs, as well as instructions on how to build them. As an important remark, *do not* choose more difficult antenna designs unless you are confident that your group can build it in the specified time frame. The goal of this project is not to force students to embark into the domain of electrical engineering, but rather for students to see how easy it is to build cheap antennas.

The simplest directional antenna design is the *cantenna*, which students predominantly choose to implement.

3   Material

Each group is given the following material:

- 1 × USB Alfa wireless adapter

- 1 × TP-Link wireless adapter

- 1 × Cable

- 1 × N-connector

At the end of the project you will return all material, *except* the N-connector. Furthermore, you will keep the antennas that you build.

We provide you with two wireless adapters. Always use the TP-Link adapter as your access point, and always use the Alfa adapter as your measurement interface, i.e., TP-Link is setup as access point and Alfa adapter is the client station that should be associated (connected) with the access point. Don't use your mobile phones or some other, public access points to perform your signal measurements. Do not change the antenna on the TP-Link adapter – always use the default omni-directional one that comes with the adapter. The reason for using the same measurement hardware is to have consistent, comparable measurements across all groups.

4   Measurements

Perform any and all measurements in wide, open spaces (e.g. fields) where no multi-path is present.

The strength of wireless signals are usually measured in Decibel-milliwatts (dBm). In what follows, you are to perform the measurements and report the observed dBm values. In order to measure the signal strength, you can use freely available software such as `wavemon`. We recommend you use your favorite Linux distribution (if you don't have Linux installed on your laptops, you can do so inside a virtual machine). For setting up the access point we recommend using `hostapd`, which you are already familiar with from earlier lab session.

Gain measurements. The goal is to convince yourself (and us) that your antenna design is *high-gain*. To do that, you will perform the following measurements. Measure how the signal strength changes when you increase the distance between the access point and the client. Start with 1 meter and increase to 10m, 20m, 40m, 60m, 80m and finally 100 meters.

Perform the above measurements by using the omni-directional antenna that comes with the Alfa adapter. Then do the same measurements with your own antenna. At the very end, you will also perform the measurements with the cantennas that we provide. In the end, for each distance, you will have 3 data points (omni-directional antenna, your antenna, our cantenna). To produce each point average the measurement over a sane amount of individual measurements.

The final plot will tell you where your antenna design lies when compared to an omni-directional antenna and a professionally-built cantenna.

Directionality measurements. You also have to show that your antenna is *directional*. Measure how the signal strength changes when you rotate the antenna. Perform all measurements at a distance of 20m. First, position your antennas so they point directly to the access point (the TP-Link). This first measurement constitutes the signal strength at 0 degrees. You will then keep your antenna distance fixed, and start rotating your antenna in 20° intervals. The final plot will show which gains your antenna provides when facing (and not facing) the access point directly.

As before, perform the above experiment with all three antennas (omni-directional, your antenna, our cantenna). For each antenna you will derive its radiation pattern based on the results of your measurements. Figure 1 shows two example radiation patterns. The radiation

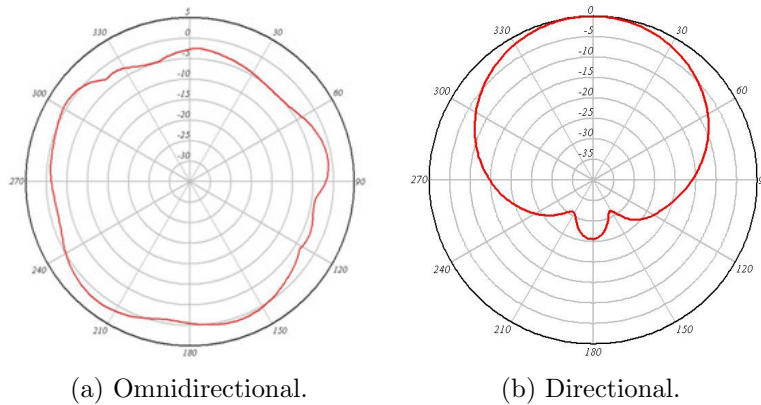(a) Omnidirectional. (b) Directional.

Figure 1: Example radiation patterns.

pattern plots will show how your antenna fares, in terms of directionality, when compared to an omni-directional antenna and a professional cantenna.

5 Report Structure

Your report should be around 5 pages and should contain two major parts. In the first part you will outline in detail the theory behind your parameter choices for designing and building your antenna. Write down any description as well as equations which support your antenna parameters (e.g. dimensions).

The second part of the report will constitute measurements as well as measurement discussion.

6 Time-frame and Grading

Consider this project as a special, out-of-band lab. Starting from the day you receive the materials from us, you will have *five weeks* to finish the project. At the end of two weeks (your original lab slot) or three weeks, we will ask you to come to our lab room and demonstrate your antenna. We will then provide you with our own antenna and you will be able to finish the measurements and writing up the report during an additional three, respectively, two weeks.

The grade of this project will count as much as the grade of 3 lab reports.

Keep in mind that the goal (or rather, requirement!) is not to produce a design that beats our own cantenna design in directionality nor gain. The goal of the lab is primarily to have fun, and to see how easy it is to build such high-gain antennas. After completing this lab, never again shall you look at an empty can of beans as something to be thrown away but rather as a *potentially powerful wireless antenna*!

Have fun!