CS6120 – Wireless Communication and Networks
Odd Sem. 2022 (July-Nov)

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Assignment 1: Fresnel zone, Free Space Loss

Due date: August 24, 2020, 11PM, On Moodle

Extension: 15 % penalty for each 24-hr period; Max. of 48-hrs past the original deadline

August 10, 2020

The purpose of this study/assignment is to apply the understanding of 1) Fresnel zones and how to design Deployments and 2) The raytracing and heat maps based on Propagation loss used in radio planning.

1 Cell Tower Calculator based on 1st Fresnel Zone

The objective of this study is to implement a Calculator, that calculates the "Cell Tower Heights" to be established on top of two buildings. The study should help student to understand the effect of the frequency used in transmission and the impact of the intermediate building heights, that impact the a) Line of sight, near line of sight and non-line of sight.
Please use : https://academy.infinetwireless.com/en/online-education/wireless-networking-fundamentals/2 - For getting the definitions of LOS, Near LOS.

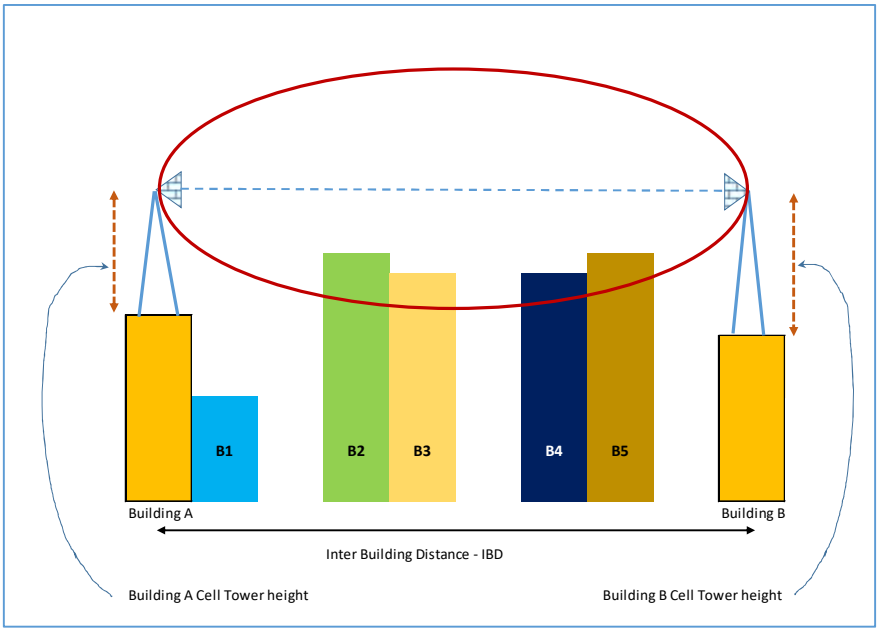


Figure 1. Cell Tower Calculator - example scenario

Goal: To determine the cell tower heights (as much as possible lower height) at Building A and Building B, so that we can achieve

a) LOS and B) Near LOS,
b) for a given frequency, with a set of buildings in between.
c) If the height of the tower exceeds 20 meters, the calculation must declare it is not feasible to make a solution.

You are given the following inputs/parameters in a file "**deploy_data.txt**"

1) Building_A_height (BAH) in meters (greater than or equal to 20 m)

2) Building_B_height (BBH) in meters (greater than or equal to 10 m)
3) Inter Building distance (IBD) in meters - (greater than or equal to 1 KM)
4) Transmission frequency
5) Number of buildings in between Building A, and Building B
6) For each Building the distance from Building A, and height of the building.

Output expected (written to a file, and online screen):
Make a program that runs as “Cell Tower height Calculator”. It has to take the input file, and generate the following output. (You can assume, Parameters 1 to 4 will be non zero and a valid one. Parameter 5 can be zero or non zero. Depending on parameter 5, there will be suitable values given as parameter 6) -

a) Solution type: LOS / Near LOS
b) Solution: Feasible / Not feasible
c) Frequency used:
d) Cell Tower A height:
e) Cell Tower B height:
f) Gap in height for each building (in between Building A and Building B) w.r.to the criteria.
g) Transmit power at Cell Tower A, if the power received at -50dbm

There must be a readme file, as how to use your program.
Program can be written in any language of your choice (C/C++, Python). Include steps as how to compile the code and execute it, any simple dependencies (don’t make it complex for evaluation).

Proof of your work, in the form of a report:
You must generate logs/output for a set of 5 input sets that you have verified.
a) Input set 1 to 3, vary the frequency (< GHz, 1 GHz to 6GHz, 28 GHz – 33 GHz), Use non zero inter building count
b) Input 4 – Vary BAH, BBH
c) Input 5 – zero inter buildings.

Share any findings / observation on height, and transmission power w.r.to the frequency.

2 Radio Planning exercise - Ray Tracing – Heat map

The objective of this study is to understand the coverage needs while planning a wireless network deployment. To support users in a given coverage region, multiple wireless devices can be deployed. The devices will reuse the frequency, i.e. each transmitter will transmit at the same frequency.

The transmitters will be spaced out suitably so that the interference created is minimal.
The transmitters can be directional i.e. tri-sector, six-sector, or omni directional.

Problem to study/solve with the following parameter and description

1. Region and Transmitter positions: For a given area say for example 2 Km by 2 Km, randomly deploy a bunch of transmitters, such that the inter transmitter distance is greater than 500 m and less than 1 KM.
2. Antenna Configuration: Assume the transmitters are supported with Tri-sector antennas.
3. Transmit power: Assume the transmission power id 30 Watts.
4. Frequency usage: For three different frequencies study the effect of signal transmission (< GHz, 1 GHz to 6GHz, 28 GHz – 33 GHz), and impact of free-space attenuation, and interference caused.

Program to study/calculate/make output
1. Measure the received signal strength at every 10 m, Identify the signal strength from nearest transmitters, and the SINR at the point.
2. Select the highest SINR for the given point, and identify the associated Transmitter.
3. Draw heat map and coverage map, i.e. how SINR varies, and what region is supported by a given transmitter.

Output expected (written to a file, and online screen):
Make a program that runs as “Coverage predictor”. It has to take the input file, and generate the following output. (You can assume, Parameters 1 to 4 will be non zero and a valid one.

For a given coverage region, set of transmitters, and given frequency, the program must generate two plots – heat map plot and coverage plot.

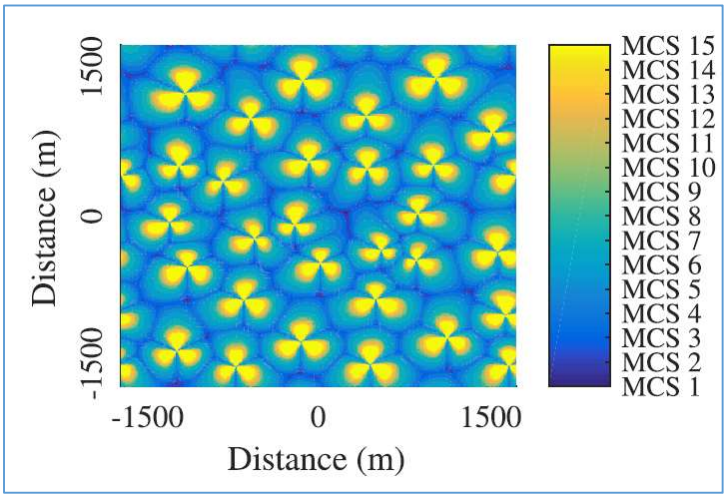


Figure 2. Sample heat map, based on tri-sector deployment. This heat map is based on the modulation and coding scheme chosen mapped to SINR at a received point.[1]

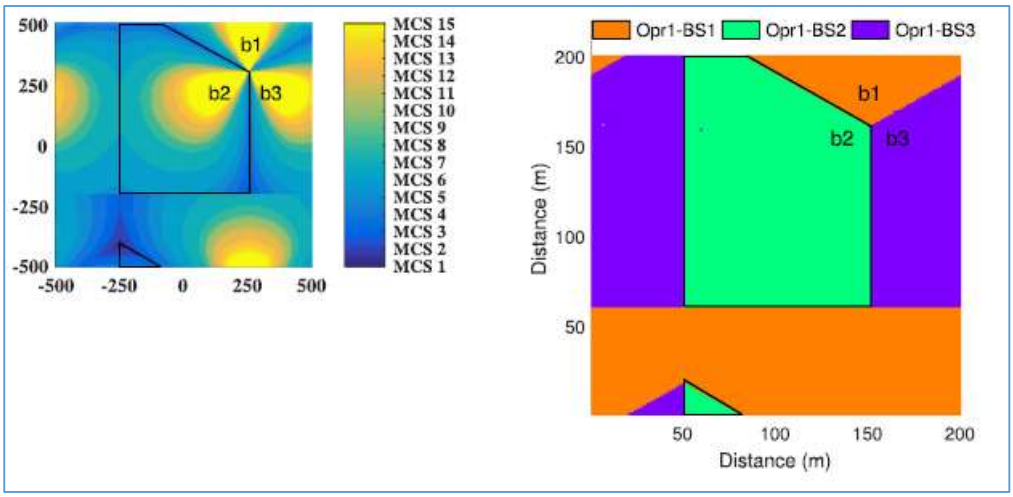


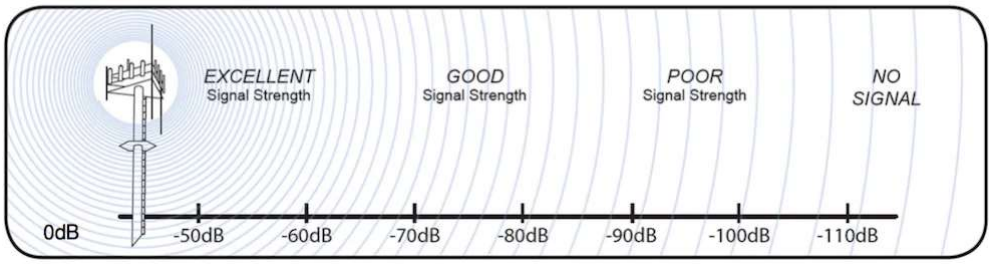
Figure 3. Heat map vs Coverage region. (Sample - Reference [2])

There must be a readme file, as how to use your program.
Program can be written in any language of your choice (C/C++, Python). Include steps as how to compile the code and execute it, any simple dependencies (don’t make it complex for evaluation).

Proof of your work, in the form of a report:
You must generate Plots for a set of 2 Transmitter position distribution for each frequencyhat you have verified.

d) Input set 1 to 3, vary the frequency (< GHz, 1 GHz to 6GHz, 28 GHz – 33 GHz), Use non zero inter building count

Share any findings / observation on Inter distance w.r.to the frequency.
How much % of the given region will have good coverage, average coverage (input guidance as per the following diagram can be used. Ref https://www.signalbooster.com/blogs/news/how-to-measure-signal-strength-in-decibels-on-your-cell-phone)



For the interest members – to get more information on ray tracing heat maps (to go beyond assignment) Aster Propagation Model - https://www.forsk.com/aster-propagation-model

3 What to Submit

The platform for this project will be Linux and C/C++ / Java / Python. Create a tar-gz file with name: Assignment1-RollNo.tgz (e.g. Assignment2-CSXXY099.tgz) that will contain a directory named Assignment1-RollNo with all relevant files.
The directory should contain the following files:
_ Source Files for both parts
_ A Makefile which generates all your executables
_ A technical REPORT (in PDF format) that discusses the results obtained by running the programs
Report your observations and analyze the results, in 1-2 paragraphs. The report
should include your name, roll number, assignment number and title.

4 Help

- Ask questions EARLY and start your work NOW. Take advantage of the help of the TAs and the instructor.
- Submissions PAST the extended deadline SHOULD NOT be mailed to the TAs. Only submissions approved by the instructor or uploaded to Moodle within the deadline will be graded.
- Demonstration of code execution to the TAs MUST be done using the student's code uploaded on Moodle.
- NO sharing of code between students, submission of downloaded code (from the Internet, Campus LAN, or anywhere else) is allowed. Code copying will result in a 'U' Course Grade. Students may also be reported to the Campus Disciplinary Committee, which can impose additional penalties.
- Please protect your Moodle account password. Do not share it with ANYONE. Do not share your academic disk drive space on the Campus LAN.
- Implement the solutions, step by step. Trying to write the program in one sitting may lead to frustration and errors.

5 Grading

- Cell Tower Calculator: 35 points
- Radio Planning exercise: 35 points
- Report: 20 points
- Viva voce: 10 points (MUST, if no viva voce not given by student, even on full report, then no points for assignment).
- NO README, NO MAKE file: -10 points each

6 References

[1] A Q-Learning Framework for User QoE Enhanced Self-Organizing Spectrally Efficient Network Using a Novel Inter-Operator Proximal Spectrum Sharing - https://ieeexplore.ieee.org/abstract/document/7582364
[2] Efficient Spectrum Slicing in 5G Networks: An Overlapping Coalition Formation Approach
https://ieeexplore.ieee.org/abstract/document/8680670