Indian Institute of Information Technology, Vadodara

CS339 - Internet Of Things

Assignment 5

Submitted By:- Priyansh Vaishnav
Student ID:- 202151120

Problem Statement: -

Write a program for finding the relation between path loss (dB) and distance between transmitter (Tx) and receiver (Rx) for the following wireless scenario

(a) Frii's equation → Free space path loss model
Hint:

- ⇒ When no obstacle exist between Tx and Rx
- ⇒ Assume no multi-path scenario has been taken.

(b) Shadowing ↔ Large scale effect
Hint:

- ⇒ Consider a obstacle between Tx and Rx.
- ⇒ Assume received power is a log-normal random variable.
- ⇒ Define the electrical behavior of obstacle.
- ⇒ Consider the factors that affect the standard deviation σ.

Solution: -

First let's outline the theoretical aspects of both scenarios given in the question:

(a) Friis's Equation - Free Space Path Loss Model

Friis's Equation describes the free space path loss (FSPL) between a transmitter (Tx) and a receiver (Rx) when there are no obstacles or reflections between them. It is given by:

$$\mathrm{FSPL} = 20\log_{10}\left(\frac{4\pi d}{\lambda}\right)$$

Where:

- FSPL is the free space path loss in decibels (dB).
- d is the distance between Tx and Rx in meters.
- λ is the wavelength of the signal in meters (speed of light divided by frequency).

(b) Shadowing - Large Scale Effect

Shadowing refers to the attenuation of a radio signal caused by obstacles (such as building) between the transmitter and receiver. This attenuation is often modeled as a log-normal random variable due to the complex nature of obstacles and their effects on signal propagation.

The total path loss (L_{tota}) in a shadowing scenario can be expressed as the sum of the FSPL (L_{FSPL}), obstacle loss ($L_{obstacle}$), and shadowing effect ($L_{shadowing}$), given by:

$L_{total} = L_{FSPL} + L_{obstacle} + L_{shadowing}$

Where:

- L_{FSPL} is calculated using Friis's Equation.
- $L_{obstacle}$ represents the additional loss due to obstacles between Tx and Rx.
- $L_{shadowing}$ is a log-normal random variable representing the shadowing effect with a standard deviation σ.

The standard deviation σ of the log-normal shadowing effect depends on various factors, including the size and material of the obstacles, the frequency of the signal, and environmental conditions.

Program: -

```
## Name: Priyansh Vaishnav      Student ID: - 202151120   ##
```

```
import math

import numpy as np


class path_lose:

    def __init__(x, freq, tx_power, g_tx, g_rx, dist, obstacle_loss=0,
shadowing_std_dev=0):

        x.freq = freq  # Frequency of operation in Hz

        x.tx_power = tx_power  # Transmit power in dBm

        x.g_tx = g_tx  # Transmit antenna gain in dBi

        x.g_rx = g_rx  # Receive antenna gain in dBi

        x.dist = dist  # Distance between Tx and Rx in meters

        x.obstacle_loss = obstacle_loss  # Obstacle loss in dB (if any)

        x.shadowing_std_dev = shadowing_std_dev  # Standard deviation for
shadowing in dB


    def free_space_path_loss(x):

        lambda_ = 3e8 / x.freq  # Wavelength in meters

        fspl = 20 * math.log10(4 * math.pi * x.dist / lambda_)

        return fspl
```

```
    def shadowing_path_loss(x):

        fspl = x.free_space_path_loss()

        shadowing_loss = np.random.normal(0, x.shadowing_std_dev)   #
Shadowing loss in dB

        total_loss = fspl + x.obstacle_loss + shadowing_loss

        return total_loss
```

To Perform this function we use an example: -

```
# For an example we use
freq = 2.4e9  # 2.4 GHz
tx_power = 20  # dBm
g_tx = 5  # dBi
g_rx = 3  # dBi
dist = 100  # meters
obstacle_loss = 5  # dB
shadowing_std_dev = 3  # dB

cal = path_lose(freq, tx_power, g_tx, g_rx, dist, obstacle_loss,
shadowing_std_dev)

# Calculate path loss for Free Space Path Loss (Friis Equation)
fspl = cal.free_space_path_loss()
print("Free Space Path Loss (Friis Equation):", fspl, "in dB")

# Calculate path loss for Shadowing
shadowing_loss = cal.shadowing_path_loss()
print("Shadowing Path Loss:", shadowing_loss, "in dB")
```

Output: -

```
Free Space Path Loss (Friis Equation): 80.0459970202808 in dB
Shadowing Path Loss: 87.59431594039098 in dB
```

The calculated Path loss using Friis's Equation is approximately 80.05 dB. This Value represents the attenuation of the signal as it propagates through free space without encountering any obstacles and the shadowing path loss is approximately 87.59dB. This value indicates the additional loss due to obstacles and the random shadowing effect.

Click here: - [Link for the python file]
