Experiment 5: Analyze the link budget for various Propagation models

1. **Aim**: To design the link budget using various path loss models
2. **Requirements:** Matlab/Scilab/Python

3. **Pre-Experiment Exercise**

   3.1 Brief Theory:

Propagations models can be used to determine the coverage area of a transmitter, transmit power requirement, battery lifetime, modulation and coding schemes required to improve the channel quality, find the maximum achievable channel capacity of the system and to find the link budget of the system. Various propagation models are

Large-scale propagation models characterize signal strength for large T-R separation (several hundreds or thousands of meters) and compute local average received power by averaging signal measurements over a track of 5 λ to 40 λ.

Small-scale propagation models are Characterize rapid fluctuations in the received signal strength over very short travel distances (a few wavelengths) in which Signal is the sum of many contributors coming from different directions. Thus phases of received signals are random and the sum behave like a noise (Rayleigh fading) where Received power may vary by as much as 3 or 4 orders of magnitude (30 or 40 dB)

Free-Space Propagation Model Predict the received signal strength when transmitter and receiver have clear, unobstructed LOS path between them. o Ex: Satellite communication system, microwave LOS system θ The received power decays as a function of T-R separation raised to some power.

Free space power received by a receiver antenna is given by Friis free-space equation (d) = $(PtGtGr*\lambda$ ^2) / ((4π) ^2 $*d$ ^2 $*L$) where

Pt is transmitted power ,
Gt, Gr is the Tx, Rx antenna gain (dimensionless quantity)
,L is system loss factor not related to propagation ($L \geq 1$). L = 1 indicates no loss in system hardware (we consider L = 1 in our calculations)
and Pr (d) is the received power and
d is T-R separation distance in meters
λ is wavelength in meters.

The gain of an antenna G is related to its affective aperture Ae by G = 4πAe / λ 2 where Ae is related to the physical size of the antenna

λ is related to the carrier frequency (λ = c/f = 2πc / ωc) where θ Isotropic radiator generally considered an reference antenna in wireless systems; radiates power with unit gain uniformly in all directions. Effective isotropic radiated power (EIRP) is the amount of power that a theoretical isotropic antenna emits to produce peak power density in the direction of maximum antenna gain.

EIRP = PtGt

Antenna gains are given in units of Db (dB gain with respect to an isotropic antenna)

Ground Reflection Model θFor large distance $d \gg hthr$

$Pr = PtGtGr/ ht$^ 2 hr ^2 d^ 4

Log distance path loss model: possible path loss values for given value of d

PL (dB)=pl(d0)+10 nlog(d/d0)

Log-Normal Shadowing Model PL(d) is random and log-normally distributed about the mean distancedependent value $X\sigma$: zero-mean Gaussian distributed random variable (in dB) with standard deviation σ

PL (dB)=pl(d0)+10 n log(d/d0)+ $X\sigma$

4. Laboratory Exercise

Procedure

Write a simulation program to understand the concept of free space model, Log distance path loss model, and log normal shadowing model

5. Post-Experiment Exercise

5.1 Conclusion

5.2 Questions:

a) Define the following terms Reflection, Refraction and Diffraction

b) Explain Need of path loss model

Reference:

Calculate the received power at a distance of 3Kms from the transmitter if the path loss exponent is 4. Assume the transmitting power is 4 Watts and at a frequency of 800MHz with a shadow effect of 10.5dbm and the path loss at a reference distance of 100m is -32dbm.Find the path loss using Log distance and Log normal model. Find the received power in both the cases