PATH LOSS & SHADOWING IN CELLULAR COMUNICATION

ECE525E – WIRELESS COMMUNICATION

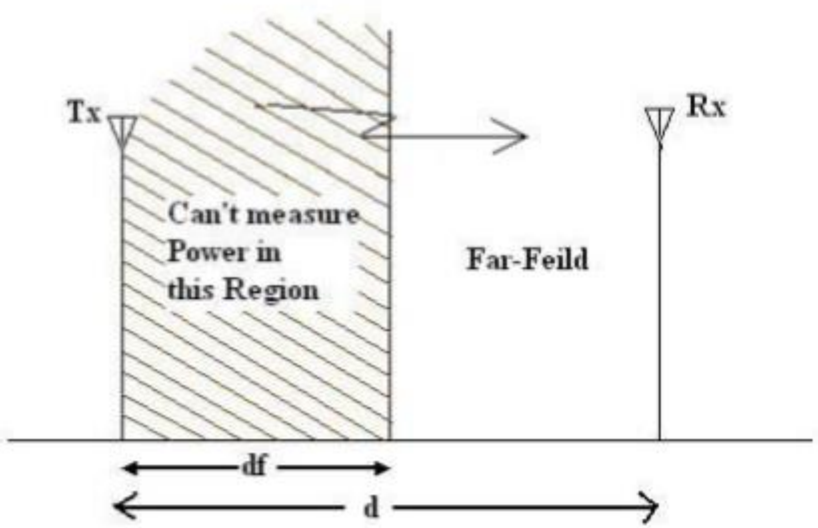
10 August 2020

RADIO WAVE PROPAGATION

Free space model predicts that the received power decays as negative square root of the distance

According to the Friis free space the received power is given by

$$P_r = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 R^2 L}$$

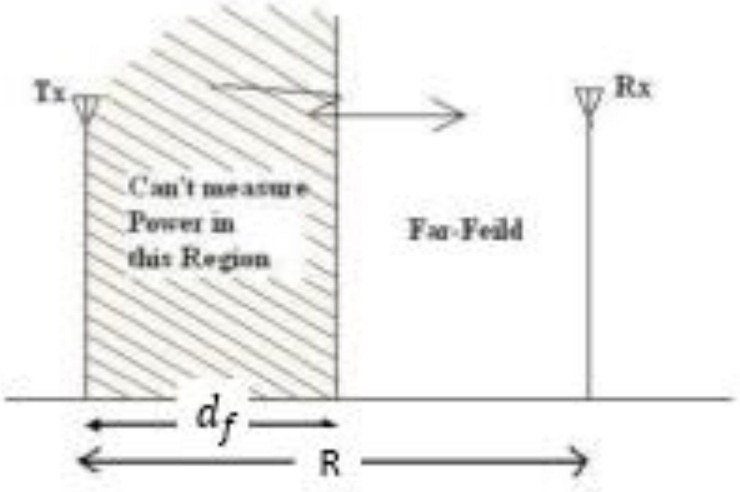


Where
P_t - transmitted power,
G_t is the transmitter antenna gain,
G_r is the receiver antenna gain,
R is the Tx-Rx separation
L is the loss factor that takes into account channel attenuation, filter losses and antenna losses and not related to propagation.

NEAR FIELD & FAR FIELD

- The fields of an antenna are broadly be classified as the near field and the far field.
- In the **far field** (also called Fraunhofer region), the propagating waves act as plane waves and the power decays inversely with distance. The Friis equation holds in this region.
- Friis equation is used only beyond the far field distance, d_f, which is dependent upon the largest dimension of the antenna, D, as

$$d_f = \frac{2D^2}{\lambda}$$



EXAMPLE

At what distance from a dipole antenna of length 1 metre does the far field commence if the operating frequency is 1800 MHz?

SOLUTION

The wavelength is given by

$$\lambda = \frac{C}{f} = \frac{3 \times 10^8}{1.8 \times 10^9} = 0.1667 \text{ m}$$

Therefore

$$d_f = \frac{2D^2}{\lambda} = \frac{2 \times 0.5^2}{0.1667} = 3\text{m}$$

EXAMPLE 2

A unit gain antenna with a maximum dimension of 1 m produces 50 W power at 900 MHz. Find

(i) The transmit power in dBm and dB,

(ii) The received power at a free space distance of 5 m and 100 m

SOLUTION

(a) (i) The transmitted power in dB = $10log_{10}$ (50) = 17 dB

(ii) Transmitted power in dBm = (17+30) dBm = 47 dBm

(b) The wavelength is $\lambda = \frac{C}{f} = \frac{3\times10^8}{9\times10^8} = 0.333$m

Therefore

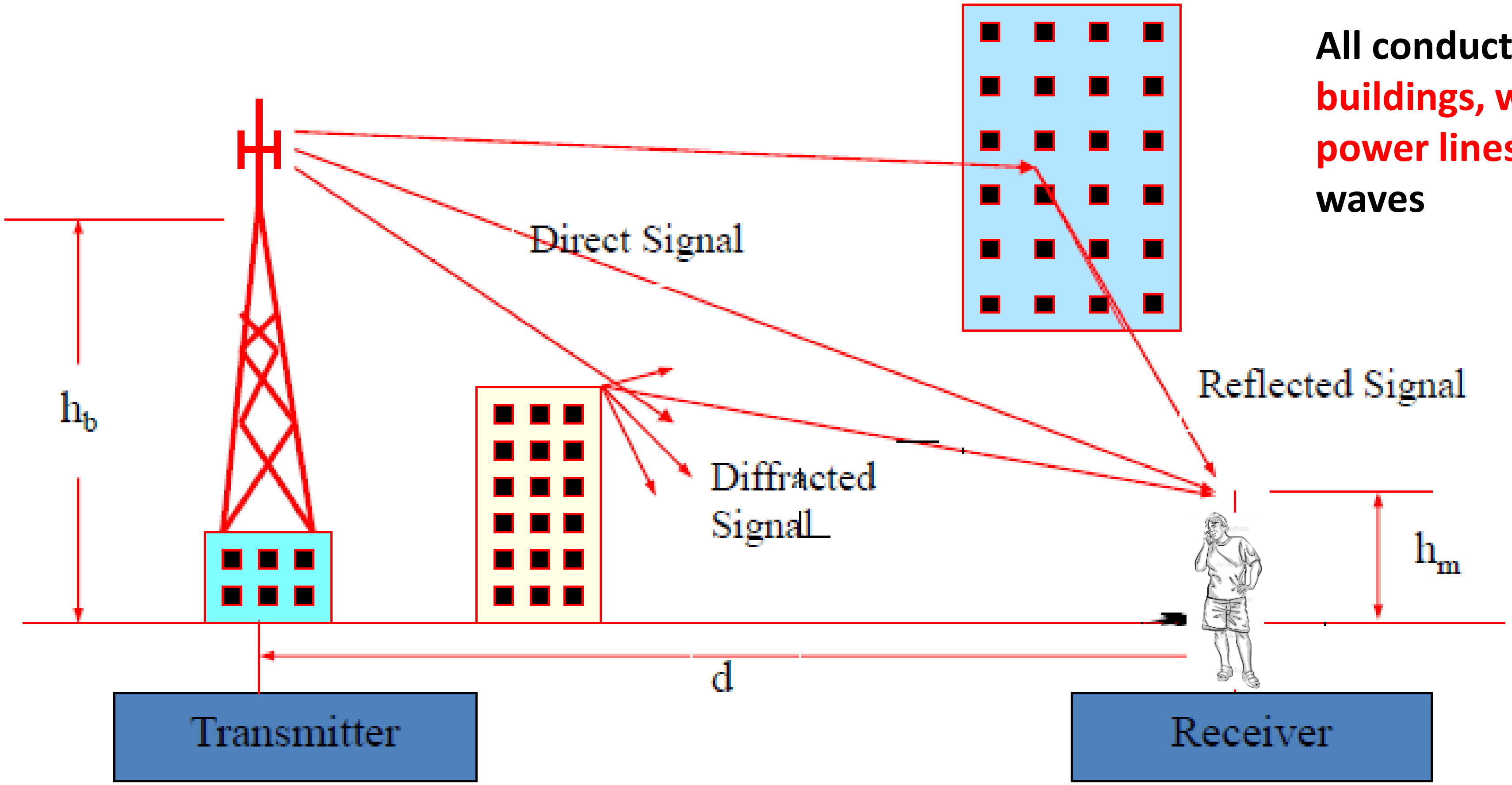
$$d_f = \frac{2D^2}{\lambda} = \frac{2\times1^2}{0.333} = 6\text{m}$$

(i) The Friss equation cannot apply at 5m which is in the near field.

(ii) At 100 m ,

$$P_r = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 R^2 L} = \frac{50 \times 1 \times (1/3)^2}{4\times3.14159^2\times100^2} = 14\mu W/m^2$$

OBJECTS THAT REFLECT RADIO WAVES IN COMMUNICATION SYSTEMS

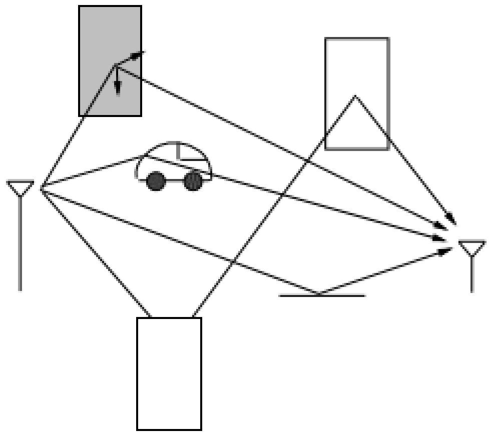


All conducting materials including buildings, water towers, vehicles, power lines, etc reflect radio waves

In urban or indoor environment, a radio signal transmitted from a fixed source will encounter multiple objects in the environment that produce reflected, diffracted, or scattered copies of the transmitted signal.

RAY-TRACING MODELS

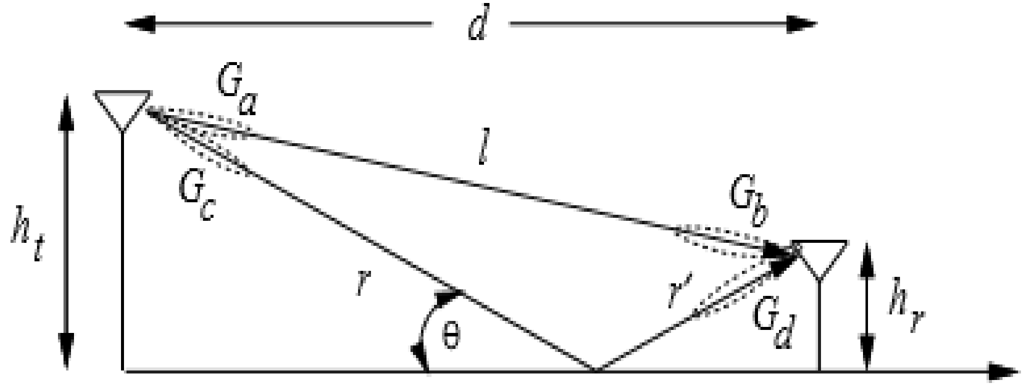
- Ray tracing Models approximate the propagation of electromagnetic waves by representing the wavefronts as simple particles arising from reflection, diffraction, and scattering effects.
- The wavefronts are then approximated using simple geometric equations.
- The error of the ray tracing approximation is smallest when the receiver is many wavelengths from the nearest scatterer, and all the scatterers are large relative to a wavelength and fairly smooth.



(a) Tracing reflected, diffracted, and Scattered Wave Components.

TWO-RAY MODEL

- The two-ray model is used when a single ground reflection dominates the multipath effect.

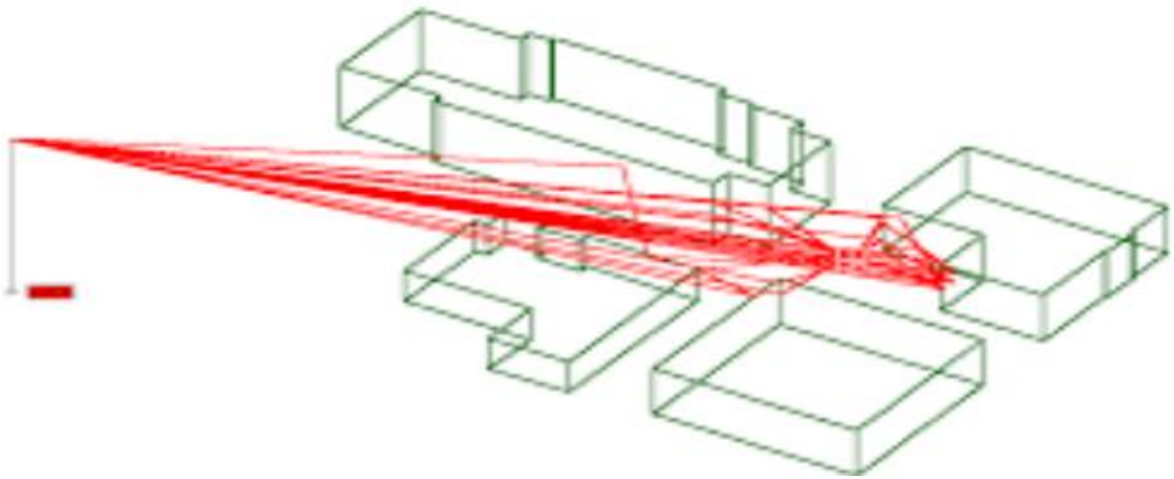


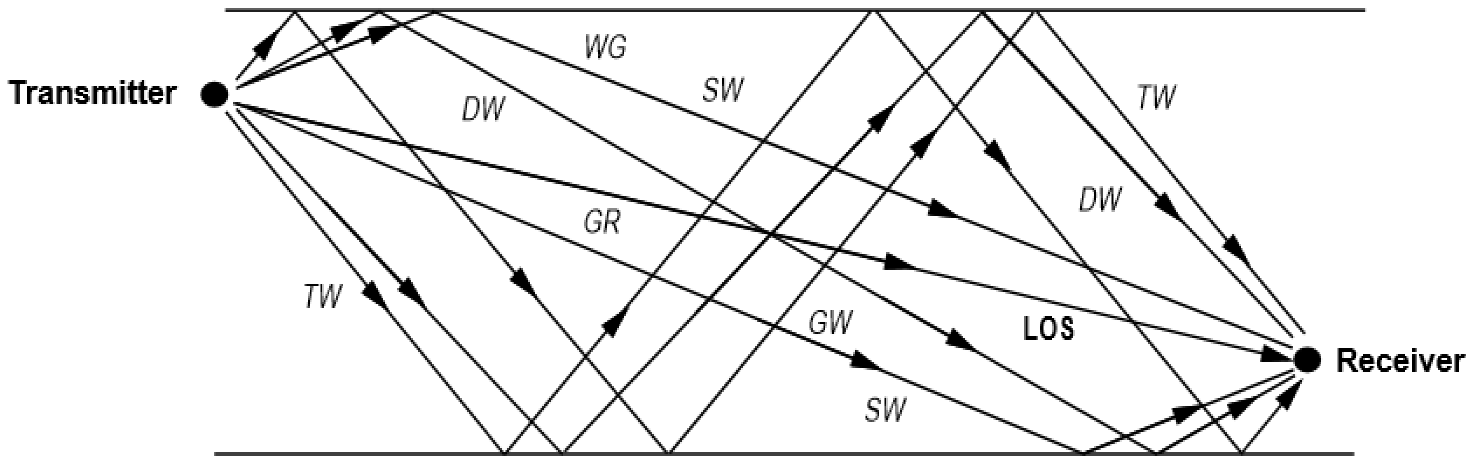
(b) Two-ray model of radio wave propagation

10-RAY MODEL

1. The 10-ray model assumes rectilinear streets with buildings along both sides of the street and transmitter and receiver antenna heights that are well below the tops of the buildings.
2. The building-lined streets act as a dielectric canyon to the propagating signal.
3. The ten rays incorporate all paths with the LOS, the ground-reflected (GR), the single-wall (SW) reflected, the double-wall (DW) reflected, the triple-wall (TW) reflected, the wall-ground (WG) reflected and the ground-wall (GW) reflected paths.

10-RAY MODEL(2)





- Ground-Reflected (GR)
- Single-wall (SW) reflected
- Double-Wall (DW) reflected
- Triple-wall (TW) reflected
- Wall-Ground (WG) reflected
- Ground-wall (GW)