Outdoor Propagation Models

- Longley-Rice model
- Durkins model
- Okumura model
- Hata model

Outdoor Propagation Models

- Radio communication over irregular terrain
- Terrain profile taken into account for predicting path loss
- Profile- varies from simple curved earth profile to highly mountainous profile
- Other propagation models- predict signal strength at a particular point from the receiver.
- Outdoor Propagation Models- Based on systematic interpretation of measured data obtained in the specific area.

Longley-Rice model

- Applicable for point to point communication system.
- Frequency---- 40Mhz to 100Ghz.
- Transmission loss---- predicted using path geometry of terrain profile and refractivity of troposphere.
- Signal strength within radio horizon---- predicted using Two ray ground reflection model
- Diffraction losses from obstacles---- predicted using Fresnel-Kirchoff, knife edge models.
- Far field diffraction losses---- predicted using Van der Pol-Bremmer method.

Longley-Rice model

- Also available as a computer program to find large-scale median transmission loss relative to free space loss btw 20MHz and 10 GHz.
- Inputs to the program ----
  - frequency
  - path length
  - polarization
  - h_t, h_r
  - surface refractivity
  - effective radius of the earth
  - conductivity and dielectric constant of the ground climate.

Longley-Rice model

- Program also works on following path specific parameter inputs---
  - Horizon distance of antennas
  - Horizon elevation angle
  - Angular trans-horizon distance
  - Terrain irregularity

Longley-Rice model

- Two modes of operation
  - Point-to-point mode prediction: when detailed terrain path profile is available and path specific parameters can be easily determined.
  - Area mode prediction: when terrain path profile is not available Longley-Rice method provides techniques to estimate path specific parameters.

Longley-Rice Model

- Urban Factor (UF)
  - Deals with radio propagation in urban areas.
  - Relevant to mobile radio.
  - An excess term as an allowance for additional attenuation due to urban cluster near the receiving antenna.

Longley-Rice Model

- Drawbacks:
  - Does not provide a way of determining corrections due to environmental factors in the immediate vicinity of the mobile receiver.
  - Does not consider correction factors due to the effect of buildings and foliage.
  - Multipath is not considered.

Okumura Model

- Widely used model for signal prediction in urban areas.
- Frequency ---- 150MHz to 1920MHz
- Distance ---- 1km to 100km
- Can be used for base station antenna heights ---- 30m to 1000m

Okumura Model

- Set of curves--- median attenuation A(f,d) relative to free space--- A_{mu}(f,d) over a quasi-smooth terrain
- h_{te}--- 200m and h_{re}---3m
- Curves developed with omni-directional antennas at both base and mobile stations.
- Frequency (100MHz to 1920MHz) and distance from base station (1km to 100km) vs median attenuation A(f,d)

Okumura Model

- Finding path loss---
  - find free space path loss (L_F) between points of interest
  - Find median attenuation relative to free space [$A_{mu}(f,d)$] from the standard curves.
  - Add L_f and $A_{mu}(f,d)$ along with correction factors (gain factors of base station antenna height $G(h_{te})$, mobile station antenna height $G(h_{re})$ and gain due to type of environment G_{AREA}) that account for the type of terrain.

Median value (50th percentile) of propagation path loss is

$$L_{50}(dB) = L_F + A_{mu}(f,d) - G(h_{te}) - G(h_{re}) - G_{AREA}$$

Okumura Model

- $G(h_{te}) = 20 \log(h_{te}/200)$ for $1000m > h_{te} > 30m$
- $G(h_{re}) = 10 \log(h_{re}/3)$ for $h_{re} <= 3m$
- $G(h_{re}) = 20 \log(h_{re}/3)$ for $10m > h_{re} > 3m$

  - Important terrain related parameters are terrain undulation height, isolated ridge height, average slope of the terrain, mixed land-sea parameter.
  - Above parameters are taken into consideration for corrective measures.

Okumura Model

- Merits
  - Simplest and best in accuracy in path loss prediction for cellular and land mobile radio systems in cluttered environments.
  - Very practical and is used in modern land mobile radio systems in Japan.
- De-merits
  - Slow response to rapid changes in terrain hence fairly good in urban and sub-urban areas but not as good in rural areas.
  - Standard deviation between predicted and measured path loss ---- 10dB to 14dB