Fundamentals of Mobile Radio Communications

Exercise 6: Okumura-Hata / COST Hata Propagation Model

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1 Basics

1.1 What variables affect propagation loss?

- Distance between transmitter and receiver
- Frequency used
- Topography (shape of the earth's surface and natural and man-made objects on the earth's surface)
- Land use (buildings, vegetation)
- Height of base station and mobile station

1.2 What is the general formula for macrocell propagation models and what do the different terms mean?

In general:

$$L_{\mathrm{dB},c}(r) = A + B \cdot \log_{10}\left(\frac{r}{\mathrm{km}}\right) + C + D$$

- A: Loss at a distance of 1 km
- B: Propagation coefficient (attenuation per decade)
- C: Diffraction attenuation due to topographical obstacles, influence of the earth's surface without buildings and vegetation
- D: Attenuation correction for land use (buildings, vegetation) in the immediate vicinity of the receiver

1.3 What is the formula for the Okumura-Hata / COST Hata model?

Based on the macrocell propagation model, Okumura and Hata developed an **empirical** propagation model by extracting the model parameters from conducted measurements.

Loss in 1 km distance A

150 MHz to 1000 MHz:

$$A = 69.55 + 26.26 \cdot \log_{10}\left(\frac{f}{\text{MHz}}\right) - 13.82 \cdot \log_{10}\left(\frac{h_{\text{Base}}}{\text{m}}\right) - a\left(h_{\text{Mobile}}\right)$$

1500 MHz to 2000 MHz:

$$A = 46.3 + 33.9 \cdot \log_{10}\left(\frac{f}{\text{MHz}}\right) - 13.82 \cdot \log_{10}\left(\frac{h_{\text{Base}}}{\text{m}}\right) - a\left(h_{\text{Mobile}}\right)$$

Both equations use an antenna height correction factor $a\left(h_{\text{Mobile}}\right)$:

$$a\left(h_{\text{Mobile}}\right) = \left(1.1 \cdot \log_{10}\left(\frac{f}{\text{MHz}}\right) - 0.7\right) \cdot \frac{h_{\text{Mobile}}}{\text{m}} - \left(1.56 \cdot \log_{10}\left(\frac{f}{\text{MHz}}\right) - 0.8\right)$$

Propagation coefficient B

$$B = 44.9 - 6.55 \cdot \log_{10}\left(\frac{h_{\text{Base}}}{\text{m}}\right)$$

Diffraction attenuation C

⇒ usually modeled using Knife-Edge model

Attenuation correction for land use D

$$D = -9.42 \cdot \log_{10}\left(\frac{f}{\text{MHz}}\right) - 1.07 + E$$

Measured correction factor E

- $E = 19.6\,\text{dB}$ for built-up areas
- $E = 11.5\,\text{dB}$ for open areas
- $E = 18.8\,\text{dB}$ for forest areas

2 Calculations using Okumura-Hata / COST Hata model

2.1 Use the Okumura-Hata model to calculate the propagation attenuation at a horizontal distance of 1 km for 900 MHz and 1800 MHz. The UE is located at a height of 1.5 m. The BS antenna height is 30 m and only 'open areas' should be considered.

2.2 What is the difference between the frequency-dependent attenuation A of the Okumura-Hata model (see 2.1) and the FSPL?

2.3 What is the received power at a point located at a distance of 1 km at a frequency of 900 MHz using the Okumura-Hata model? The EIRP of the base station is 60 dBm and the antenna gain of the MS is estimated to be 0 dBi (isotropic omnidirectional radiator).

2.4 The maximum EIRP of a radio system in downlink transmission is $EIRP = 50$ dBm. What would be the maximum allowed distance between a mobile station ($h_{\text{Mobile}} = 2$ m, isotropic antenna) and a base station ($h_{\text{Base}} = 30$ m) in a 'built-up area' if the receiver sensitivity is -104 dBm, the combined reserves and losses are 8 dB and the carrier frequency is 1800 MHz? Use the Okumura-Hata model for the estimation.