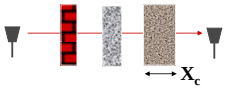
EE359 – Lecture 3 Outline

- Announcements
  - First disc. Section Tues. 10/4, 6-7, Hewlett 103
  - HW posted, due Thurs 10/6 at 5pm.
  - Nima OHs: Tues. 7-9PM in Packard 109; Wed. 7-9PM in Packard 104
  - Nima Email Ohs: Wed. 10-11PM - Thurs 10-11AM
- Log Normal Shadowing
- Combined Path Loss and Shadowing
- Cell Coverage Area
- Model Parameters from Measurements

Lecture 2 Review

- Ray Tracing Models
- Free Space Model
  - Power falloff with distance proportional to d^{-2}
- Two Ray Model
  - Power falloff with distance proportional to d^{-4}
- General Ray Tracing
  - Used for site-specific models
- Empirical Models
- Simplified Model: $P_r = P_t K [d_0/d]^\gamma$, $2 \le \gamma \le 8$.
  - Captures main characteristics of path loss

Shadowing

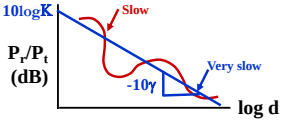


- Models attenuation from obstructions
- Random due to random # and type of obstructions
- Typically follows a log-normal distribution
  - dB value of power is normally distributed
  - μ=0 (mean captured in path loss), $4 < \sigma < 12$ (empirical)
  - LLN used to explain this model
  - Decorrelated over decorrelation distance X_c

Combined Path Loss and Shadowing

- Linear Model: ψ lognormal

$$\frac{P_r}{P_t} = K\left(\frac{d_0}{d}\right)^\gamma \psi$$

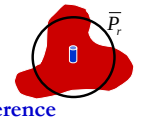


- dB Model

$$\frac{P_r}{P_t}(dB) = 10\log_{10} K - 10\gamma \log_{10}\left(\frac{d}{d_0}\right) + \psi_{dB},$$

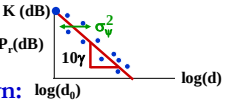
$$\psi_{dB} \sim N(0, \sigma_\psi^2)$$

Outage Probability and Cell Coverage Area



- Path loss: circular cells
- Path loss+shadowing: amoeba cells
  - Tradeoff between coverage and interference
- Outage probability
  - Probability received power below given minimum
- Cell coverage area
  - % of cell locations at desired power
  - Increases as shadowing variance decreases
  - Large % indicates interference to other cells

Model Parameters from Empirical Measurements



- Fit model to data
- Path loss (K,γ), d_0 known:
  - "Best fit" line through dB data
  - K obtained from measurements at d_0.
  - Exponent is MMSE estimate based on data
  - Captures mean due to shadowing
- Shadowing variance
  - Variance of data relative to path loss model (straight line) with MMSE estimate for γ

Main Points

- Random attenuation due to shadowing modeled as log-normal (empirical parameters)
- Shadowing decorrelates over decorrelation distance
- Combined path loss and shadowing leads to outage and amoeba-like cell shapes
- Cellular coverage area dictates the percentage of locations within a cell that are not in outage
- Path loss and shadowing parameters are obtained from empirical measurements