ELC 5396: Digital Communications

Liang Dong

Electrical and Computer Engineering
Baylor University

liang_dong@baylor.edu

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How to combat the degrading effect of multipath and thereby realize reliable communication over a fading channel. *Space Diversity*
Propagation Effects
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Transmit Antenna  Multipath Component  Receive Antenna

www.antenna-theory.com
Propagation Effects

Log(Pr/Pt)

- Path loss
- Shadow + Path loss
- Multipath + Shadowing + Path loss
Small-scale Multipath Fading

$V = 0.5 \text{Km/h} \rightarrow f_D = 8.33 \text{Hz}$

$V = 100 \text{Km/h} \rightarrow f_D = 167 \text{Hz}$
Jakes Model

[Diagram showing a model of signal transmission with labels for Tx, Rx, BS, MS, Scatterers, R, \( \gamma \), and \( \theta \).]
Rayleigh fading with Doppler frequency 10 Hz.
Signal bandwidth vs. The reciprocal of the spread in propagation path delays

Coherence bandwidth

\[ B_c \approx \frac{1}{D} \]

“Wideband” when the signal bandwidth significantly exceeds the coherence bandwidth of the channel
y(t) = \int_{-\infty}^{\infty} h(\tau; t)x(t - \tau) \, d\tau

H(f; t) = \int_{-\infty}^{\infty} h(\tau; t)e^{-j2\pi f \tau} \, d\tau

Channel assumptions:

- $h(\tau; t)$ is wide-sense stationary.
- Uncorrelated Scattering: Contributions from two or more scatterers with different propagation delays are uncorrelated.

$$R_h(\tau_1, t_1; \tau_2, t_2) = \mathbb{E}[h^*(\tau_1; t_1)h(\tau_2; t_2)]$$

$$= \underbrace{r_h(\tau_1; \Delta t)}_{\text{multipath correlation profile}} \delta(\tau_1 - \tau_2)$$
Channel is viewed in the frequency domain.

- A multipath channel is said to be *frequency selective* if the coherence bandwidth of the channel is small compared with the bandwidth of the transmitted signal.
- A multipath channel is said to be *frequency nonselective*, or *frequency flat*, if the coherence bandwidth of the channel is large compared with the transmitted signal bandwidth.
Classification of Multipath Channels

Channel is viewed in the time domain.
• The fading is *time selective* if the coherence time of the channel is small compared with the duration of the received signal (i.e., the time for which the signal is in flight).
• If the channel’s coherence time is large compared with the received signal duration, then the fading is said to be *time nonselective*, or *time flat*.

Channel coherence time is inversely proportional to the Doppler spread.

\[
\tau_c = \frac{1}{\sigma_fd}
\]