EEE 6109 Wireless Communication.

Dr. Ciira Maina
ciira.maina@dkut.ac.ke

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Today's Lecture

1. Statistical Description of the Wireless Channel

Introduction

- It is more practical to describe the wireless channel statistically
- We determine the probability of a channel parameter attaining a certain value
- Over short distances, received power fluctuates around a mean value - small scale fading
- Over larger spatial dimensions (around 10 wavelengths), large scale fading occurs due to shadowing

Time Invariant Two-path model

- Let's consider a simple model of time invariant propagation along two paths
- Assume the transmitted signal is

$$E_{TX}(t) \propto \cos(2\pi f_c t) \tag{1}$$

- The received signal is

$$E(t) = E_0 \cos(2\pi f_c t - k_0 d) \quad k_0 = \frac{2\pi}{\lambda} \tag{2}$$

- In complex baseband notation we have $E = E_0 \exp(-jk_0 d)$

Time Invariant Two-path model

- If the signal gets to the RX via two paths with different runtimes, $\tau_1 = \frac{d_1}{c_0}$ and $\tau_2 = \frac{d_2}{c_0}$
- We have

$$E(\mathbf{r}) = E1 \exp(-j\mathbf{k}_1\mathbf{r}) + E2 \exp(-j\mathbf{k}_2\mathbf{r}) \qquad (3)$$

- We assume th absolute amplitude of the signals does not vary as a function of RX position

Time Variant Two-path model

- Assuming the RX moves, the runtimes change as a function of time
- The spatial fading is time varying fading
- Movement of the RX results in shift of received frequency - Doppler shift

$$E(t) = E_0 \cos(2\pi f_c t - k_0[d_0 + vt]) \tag{4}$$

- The doppler shift is given by

$$\upsilon = -\frac{v}{\lambda} = -f_c \frac{v}{c_0} \tag{5}$$

- The Doppler shift is negative when the TX and RX move away from each other
- Different paths experience different doppler shift resulting in beating
- This can impair reception of AM signals

Small Scale Fading without a dominant component

- We assume the amplitude of the MPCs a_i doesn't vary over the region of observation

$$\sum_{i=1}^{N} |a_i|^2 = C_P \tag{6}$$

- The phase of each component is assumed to be uniformly distributed over $[0, 2\pi]$
- The distribution of the phase of the received signal is also uniformly distributed over $[0, 2\pi]$
- The distribution of the magnitude of the received signal is given by the Rayleigh distribution

$$p(r) = \frac{r}{\sigma^2} \exp\left(-\frac{r^2}{2\sigma^2}\right) \quad 0 \leq r < \infty \tag{7}$$

- The CDF of the Rayleigh distribution is

$$1 - \exp\left(-\frac{r^2}{2\sigma^2}\right) \tag{8}$$

Example 5.1 in Molisch

Readings

- Molisch - Chapter 5