Name: Kevin Jiang

Date:2/19/2020

Paper Title: Theory of Multipath Shape Factors for Small-Scale Fading Wireless Channels

Author Names: Gregory D. Durgin and Theodore S. Rappaport

Year Published: 2000

Open questions for discussion in class:

-When is a Rayleigh channel used in practical applications such as Wi-Fi?

-What affects the static-ness of a channel?

-What exactly does the average fading rate do to a signal propagating through space?

The topic areas covered by the paper are:

-Adding on to the classical theory of analysis of omnidirectional multipath waves with concepts that can be used for analysis of non-omnidirectional multipath waves

-Three Multipath Shape Factors: Angular Speed, Angular Constriction, and Azimuthal Direction of Maximum Fading

-Rate Variances of three basic stochastic processes in small-scale fading analysis (Complex Received voltage, Received Power, Received Envelope), expressed in terms of the three shape factors

-Quantitative analysis of different non-omnidirectional propagation channels using shape factors and seeing how they affect average fading rate of signals

-Four second order statistics used in small-scale fading channels, particularly Rayleigh Channels (Level-Crossing Rates and Average Fade Duration, Spatial Autocovariance, and Coherence Distance)

The previous approaches to this problem were:

-The previous approaches to modeling multipath channels were omnidirectional channels, were waves were assumed to arrive to the receiver with equal power in all directions on a horizontal plane. However, measurements have shown that this model is far from accurate.

Outline the basic new approach or approaches to this problem:

-Define three multipath shape factors that can be used to quantitatively analyze non-omnidirectional channel models, which are closer to reality

-These three multipath factors are used in four different non-omnidirectional models to show how they affect the average rate at which a received signal fades.

-The multipath shaping factors are then used to derive four second-order small-scale fading statistics, which are then used to revisit classical omnidirectional models to demonstrate that shape factor theory can also be generalized to use in classical models. Specifically, the three shape factors will take on specific values when applied to a classical model.

Critical assumptions made include:

-The quantitative analysis made in the paper assumes static channels. In reality, channels can have largely varying transient behavior. Additionally, everything that the paper derives only extends to the horizontal 2D wave model (which are typically used), but with further work, shape factors can extend to include 3D waves.

The performance of the techniques discussed in the paper was discussed in what manner:

-The use of shape factors in determining the average fading rate of a signal within a channel was demonstrated through four different models. Shape factors were then applied to the classical model to achieve the same results, showing that shape factors can be extremely versatile in their use for analysis.

The following terms were defined:

-Angular Spread: A measure of how multipath concentrates about a single azimuthal direction. Shape factor.

-Angular Constriction: A measure of how multipath concentrates about two azimuthal directions. Shape factor.

-Azimuthal Direction of Multiple Fading: The third Shape factor, can be thought of as an orientation parameter

-Rate Variance of Complex Received Voltage: The average complex voltage fluctuations for a mobile receiver

-Rate Variance of Received Power: The average received power fluctuations in a Rayleigh fading local area.

-Rate Variance of Received Envelope: The average received envelope fluctuations in a Rayleigh fading local area.

-Two-wave Channel Model, Sector Channel Model, Double Sector Channel Model, Rician Channel Model, these are all channel models with waves coming from different directions and different angular coverage.

-Rayleigh fading signal: A signal whose envelope follows the Rayleigh PDF.

- Level-Crossing Rates and Average Fade Duration, Spatial Autocovariance, and Coherence Distance, these are second-order statistics, not really defined but derived using shape factors.

I rate and justify the value of this paper as:

-This paper provides an effective method to analyze non-omnidirectional channels, which sounds like quite the breakthrough. The method can analyze any kind of channel that is closer to reality and can still be applied to classical models. The difficulty of the paper is quite high and requires some prior knowledge of how second-order statistics and the significance of Fourier coefficients.
9/10