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Point-to-Point Systems – Propagation Loss Models and Measurements at 5.8GHz and 3.5GHz

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1. Extended Abstract

The Torrico-Bertoni-Lang model [1] has been used to predict and compare against measurement the propagation loss for point-to-point systems in a vegetated residential area at 5.8 GHz and 3.5 GHz. Here a vegetated residential area is defined as an area outside of the high-rise core of a city, where the heights of the houses are relatively uniform and the tree canopies are located in front of each house to form nearly a continuous row of trees along the street. The base-station transmitter is located above or close to the surrounding rooftops. The receiver, in many cases, is also located close to the surrounding rooftops or below them and it is fixed at a particular height; the propagation takes place over the rooftops and/or through the canopy of the trees. The measurements were performed in a well-established and mature residential area in greater Washington DC. In order to compare the theoretical propagation model vs. the measurements, the terrain and the morphology data were obtained where the measurements took place. The terrain data used was from the United States Geological Survey (USGS) with 1/9 arc second resolution. The building data was obtained from the Light Detection and Ranging (LiDAR) data, and the vegetation data used was from the USGS NLCD 2011.

The point-to-point measurements were performed at 5.8 GHz and at 3.5 GHz in a landscape rather flat and consisted of vegetated residential areas. At 5.8 GHz, the transmitter was a Hewlett Packard signal generator that generated a continuous wave (CW) RF signal. At 3.5 GHz, the transmitter was a Berkeley Varitronics Class A Gator signal generator that generated also a CW RF signal. . A CRFS RFeye spectrum monitor with a receiver sensitivity of -130 dBm at 3.5GHz and 5.8GHz was used to collect the measured data. The transmitter for both frequencies, was located at 47 m above ground and well above the average rooftops. At 5.8 GHz, eleven receivers site were selected to provide path obstruction due to rooftops of the houses only. Instead, at 3.5 GHz, sixteen receiver sites were selected to provide two types of obstruction scenarios. The first scenario was selected to provide path obstruction due to rooftop of the houses only, and the second scenario to provide path obstruction by the rooftops and the canopy of the trees simultaneously.

Following the Torrico-Bertoni-Lang model [1], each row of houses is viewed as diffracting cylinders and a canopy of the trees located adjacent to and above the houses. In this scenario, the diffracting cylinders where modeled as absorbing screens and the adjacent canopy of trees by partially absorbing phase screens. The field at the aperture of the first absorbing screen depends on the mean field going through the first tree due to an incident plane wave. Then, physical optics (PO) is used to evaluate the diffracting field at each of the successive absorbing/phase half-screens configuration up to the mobile receiver by using the multiple Kirchhoff-Huygens integration. In order to find the properties of a partially absorbing phase screen, the attenuation and phase delay of the mean field propagating through the canopy is evaluated using a random media model. The tree canopy is represented as an ensemble of leaves and branches all having prescribed location and orientation statistics. Leaves are modeled as flat, circular, lossy-dielectric discs and branches as finitely long, circular, lossy-dielectric cylinders. The mean field in the canopy is calculated using the discrete scattering theory of Foldy-Lax. By solving the wave equation for the mean scattered field propagating through a tree, it is found that the wave propagation constant has both real and imaginary components. The integral effect of the propagation constant over the tree volume leads to expressions for the attenuation and phase delay of the partially absorbing phase screen. Comparison between the measurements and the predictions shows the importance of including the real and the imaginary components of the propagation constant of the canopy of the trees, at high frequencies, in the overall propagation loss in a vegetated residential environment between a transmitter and a receiver. Backscattering effects from the tree canopy have been neglected. Results show that by using a physical-base propagation model and GIS data, a close correlation between measurements and predictions are obtained.

2. Reference

1. S. A. Torrico, H. L. Bertoni, and R. H. Lang, “Modeling tree effects on path loss in a residential environment,” *IEEE Transactions on Antennas and Propagation*, vol. AP-46, no. 6, pp. 872-880, June 1998.