Macro-Modeling of Path-Loss through Foliage Using SWAP Algorithm

Feinian Wang and Kamal Sarabandi
Radiation Laboratory, The University of Michigan, Ann Arbor, MI 48109

The presence of foliage at either rural or residential environments affects wireless communication channel characteristics including path-loss and signal fading statistics. Accurate and simple-to-use foliage path-loss models are of great interest for both civilian and military applications. Existing foliage propagation models can be categorized into two groups. The first group of models, such as Wiessberger model, is empirically constructed based on measurement results from a particular foliage and at a certain frequency band. These models do not include important foliage parameters, such as the tree structures, moisture condition, and the biomass, which differentiate various foliages and significantly affect the path-loss. Since conducting path-loss measurement for each specific foliage condition is prohibitively time-taking and expensive, the second group of models take an alternative way by constructing foliage path-loss model through analytical and numerical simulations. Recently physics-based wave propagation models using wave theory have attained significant prominence. Such a model has been developed that computes the field through a layer of foliage by accounting for attenuation and the scattering from constituents of realistic-looking fractal trees coherently. Monte-Carlo simulations are used to provide the statistics of wave propagation through foliage. The tree stands are generated with physical and structural parameters, such as tree density and height, from ground truth measurements, in order to preserves the fidelity of the model. Based on this approach, a statistical wave propagation (SWAP) model is developed to compute the path-loss versus propagation distance within foliage. In this model the foliage is divided into statistically identical blocks through which the statistical scattering and attenuation is computed using the coherent model. Cascading many such blocks, the wave propagation through foliage of arbitrary length is computed. This model is very powerful and accurate, but it still requires significant computation time and is not simple to use. In this paper, a simple but accurate path-loss macro-model based on the simulations of SWAP algorithm is constructed.

Generally the path-loss curve as a function of distance has a dual-slope property, i.e. the attenuation rate transits from one value to a smaller quantity after certain propagation distance (knee point). The two attenuation rates, the knee point, and the associated attenuation value are modeled empirically in terms of foliage parameters, radio frequency, and polarization. Comparison of path-loss values obtained from the macro-model and experimented data is also presented.