The Radiative Transport Theory – Mobile-to-Mobile Communication in a Trunk Dominated Forest: Probability Density of the Received Intensity

Cuneyt Utku(1), Saúl A. Torrico(2), and Roger H. Lang* (3)
(1) Dept. of Electrical and Electronics Engineering, Istanbul Sehir University, Istanbul, Turkey
(2) Comsearch, 19700 Janelia Farm Blvd., Ashburn, VA 20147 USA
(3) Dept. of Electrical and Computer Engineering, The George Washington University, Washington, DC 20052, USA

As a new generation of wireless communication systems is being proposed, there is a new interest in deploying mobile-to-mobile systems to interconnect the wireless network in forest environments. Deploying mobile-to-mobile systems in forest environments, however, does not guarantee a direct line-of-sight path between the transmitter and receiver. Therefore, it is of practical interest to determine the effect of attenuation in this type of environment. In addressing this interest, there are two objectives of this presentation. The first objective is to demonstrate that the 2D-Radiative Transport (RT) equation is an effective and a practical way of assessing the attenuation in a trunk dominated forest. This is accomplished by comparison with Monte Carlo simulations for a layer of parallel dielectric cylinders. The second objective is to use the simulation approach to find the probability density function (pdf) of the signal amplitude and intensity.

In this study, it is assumed that the transmitter and the receiver are at the same height and that the effects of the ground are not included. Under these assumptions, the waves that travel between the transmitter and the receiver propagate in a plane parallel to the ground, essentially rendering the problem two-dimensional. The forest can now be considered as a slab of randomly distributed parallel cylinders. By using the circular symmetry of the trunk and assuming that the transmitter and the receiver are in the same transverse plane, the radiative transport equation is solved numerically by the eigenvalue technique. The solution is then used to compute the attenuation constant in a trunk-dominated forest. The transport theory is employed to study the effects of multiple scattering for a two-dimensional forest of lossy tree trunks. With all trunks assumed identical, the phase function, appearing in the exact RT equation, is obtained from the differential scattering cross section of an infinite length lossy dielectric cylinder. The intensity inside a 500 meter thick forest is considered.

A Monte-Carlo simulation approach is used to solve the same problem treated by the transport approach. The problem is formulated using Maxwell's equations in the low frequency limit. The electric field is computed for 5000 Monte-Carlo realizations corresponding to different placements of the cylinders and then the results are averaged to estimate the intensity. It is found that attenuation of the intensity computed by this simulation technique agrees with the attenuation computed by the transport results. The simulation approach is also used to compute the pdf of the magnitude of the electric field as a function of propagation distance into the slab. It is shown that the simulation results can be fitted quite closely with a Rician distribution at multiple depths within the forest layer.