2-D Radiative Transport Theory – Forward Scattering Approximation: Mobile-to-Mobile Communication in a Trunk Dominated Forest

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As a new generation of broadband wireless communication systems is being proposed to meet the increased demand for data capacity, there is a new interest in deploying high-performance microwave backhauls, at millimeter frequencies, to interconnect the wireless network in urban/suburban/forest environments. Deploying high-performance microwave backhauls in urban/suburban/forest environments, however, does not guarantee a direct line-of-sight between the transmitter and receiver base stations. A substantial number of backhaul small cells in urban/suburban or forest settings do not have a clear line-of-sight to the network; they are either blocked by houses, trees, or both. It is of practical interest to determine the effect of attenuation at these millimeter frequencies. The objective of this presentation is to demonstrate that the use of the forward scattering approximation to solve the Radiative Transport (RT) equation at millimeter frequencies is an effective and a practical way of assessing the attenuation in a trunk dominated forest. The solution of the exact RT equation at millimeter wave frequencies is computationally much more intensive than the solution of the RT equation under the forwarding scattering approximation.

In this study, it is assumed that the transmitter and the receiver are at the same height and that the effects of the ground can be neglected. 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. Using this 2-D assumption, we solve exactly the 2-D RT equation. We then compare the exact solution to the solution of the transport equation under the forward scattering approximation.

The exact RT equation is solved numerically by the discrete ordinate analysis technique. The phase function, appearing in the exact RT equation, is obtained from the differential scattering cross section of a lossy dielectric cylinder. The forward scattering approximation, on the other hand, is used to simplify the RT equation. It takes advantage of the fact that, at millimeter frequencies, the radius of the trunks is large compared with the wavelength; hence, a trunk scatters energy strongly in the forward direction and weakly in other directions. Thus, for computational convenience, we approximate the phase function by a delta function in the forward scatter direction.

The results of this study show the difference in forest attenuation as computed by the exact and the approximate forward scattering approximation at millimeter wave frequencies. The difference between the two approaches is due to the fact that the forward scattering approximation does not include all the multiple scattering effects especially as the propagating wave travels deeply into the forest.