Channel Model Comparison for 28 GHz Millimeter Wave in Suburban and Rural Environments

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With the rapid standardization process of 5G, millimeter waves have garnered great attention worldwide from industry, academia and government. To incorporate millimeter wave bands into future wireless telecommunication networks, one of the biggest challenges is to better understand the propagation characteristics of millimeter wave signals and accordingly predict channel states for network planning and operation as needed. To address this, intensive millimeter wave channel measurement campaigns have been carried out for urban environments during the past few years. However, very limited effort has been put into comparing and validating currently available channel models for millimeter waves in suburban and rural environments.

To explore this research gap, we carried out two measurement campaigns at 28 GHz, using a 400-megachip-per-second custom-designed broadband sliding correlator channel sounder and highly directional 22-dBi (15° half-power beamwidth) horn antennas, and accordingly evaluated the performances of several traditional channel models. The first measurement campaign was carried out at the United States Naval Academy in Annapolis, Maryland, focusing on suburban environments. The transmitter was installed at a height of 90 feet (27.4 m) to emulate a microcell deployment. The receiver was moved around campus by an electric car or a two-layer platform trolley to obtain the measurements. More than 5000 power delay profiles were obtained over distances from 80 m to 1000 m at 50 individual sites and on two pedestrian paths. The resulting basic transmission losses were compared with predictions of the close-in free space reference distance model, the alpha-beta-gamma model, and the over-rooftop model in recommendation ITU-R P.1411-9, for the line-of-sight data and the none-line-of-sight data, respectively. The second measurement campaign was conducted in a coniferous forest near Boulder, Colorado and we obtained in total 1415 basic transmission loss measurements. With the transmitter set up at the edge of the forest, the receiver was installed in a backpack and powered by a drone battery for portability. A comprehensive model comparison, for partition-dependent attenuation factor propagation model, Weissberger's model, and the obstruction by woodland model from ITU-R P.833-9, is provided to elucidate the pros and cons of different modeling approaches for predicting millimeter wave signal attenuation through vegetation. Our analyses for these campaigns reveal that the traditional channel modeling approaches could be improved to better deal with the varying site-specific propagation of millimeter waves in suburban and rural environments.