A Comparative Study of Radiowave Propagation Models for Urban and Suburban Paths

Ozlem Ozgun*
Hacettepe University, Department of Electrical and Electronics Engineering, Ankara, Turkey

Accurate modeling of electromagnetic wave propagation over long distances has long been interest in various areas, such as radar and communication systems, target detection and tracking, imaging and remote sensing. Since the domain of interest is very large in wavelengths, numerical methods like method of moments, finite difference and finite element methods (as well as some commercial software like HFSS, CST, etc.) are not applicable due to large number of unknowns required to solve such long-range propagation problems. In earlier times, some empirical models were used to estimate propagation effects based on curve-fitting of measured field response. Furthermore, some theoretical models were proposed, such as Longley-Rice model, Bullington model, Lee's model, and Walfisch and Bertoni model, in which the environment is represented by some canonical parameters/geometries, such as building geometry, spacing, etc. However, the main drawback in these models is that they are accurate for specific parameters and environments, and they do not become valid in complex propagation scenarios.

There are also ray-based approaches (such as geometrical optics (GO), geometrical theory of diffraction, uniform theory of diffraction (UTD), physical optics and physical theory of diffraction), which provide accurate formulations to model main propagation mechanisms, such as reflection, refraction and diffraction. Recently, a MATLAB-based tool (called GO+UTD) was developed by combining the GO and UTD models (*O. Ozgun, IEEE Antennas Propag. Mag., 58, 91-103, 2016*). Rather than point-to-point calculations, it predicts the signal strength and path loss in a whole coverage area. It is based on an algorithm that divides the terrain or buildings/objects into a number of line segments, and superposes the incident and multiple reflected and diffracted fields in an automatic manner by repeatedly utilizing the GO and UTD principles according to different line-of-sight conditions.

In addition, the parabolic equation (PE) method is an efficient numerical method to model arbitrary refraction effects and ground irregularities in long-range propagation problems. It is based on an approximate form of the Helmholtz wave equation, and can be solved by a marching type algorithm, which allows to solve propagation problems in a fast manner. A two-way PE model was implemented as a MATLAB-based tool for propagation problems, and called PETOOL (*O. Ozgun, et. al., Comput Phys Commun, 182, 2638–2654, 2011*).

In this study, a comparative study of the numerical models (GO+UTD and PETOOL) and Walfisch's theoretical model (*J. Walfisch, H. L. Bertoni, IEEE Trans Antennas Propag, 36, 1788–1796, 1988*) is presented in the solution of two-dimensional urban and suburban radiowave propagation problems. The results are compared through several numerical simulations performed in different scenarios. Computational aspects of the models are discussed.