Simplified Analysis of Indoor Radio Wave Propagation at 2.4GHz Band

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Abstract

According to the recent spread of wireless LAN systems based on IEEE802.11 at 2.4GHz band, it has been one of the most important research topics to investigate how radio waves propagate inside office environments, because local objects like pillars, walls, doors and windows may reduce the link performance of such low power wireless systems.

For outdoor environments like urban complex, ray tracing/shooting techniques based on Geometrical Theory of Diffraction (GTD) like the Vertical Plane Launch (VPL) method (H. L. Bertoni, *Radio Propagation for Modern Wireless Systems*, Prentice Hall, 2000) have been widely applied to the analyses of the wave propagation modelings, because the approximate ways provide easy and accurate propagation prediction with physical insight and give high computer efficiency for such large models. However, such ray based techniques may not be suitable to analyze indoor propagation models since there may be lots of transmitted fields through dielectric walls and glasses. One may be able to treat the reflected field contribution from the surface with the aid of the impedance boundary conditions, but not for the transmitted fields.

While, the Finite Difference Time Domain (FDTD) method, which is widely used for microwave and antennas analyses, may provide us an easy evaluation procedure for the complex propagation behavior of the fields inside the dielectric materials like walls and glasses. However, enormous memory size must be required for precisely modeling an office floor at 2.4GHz band, especially for 3D modeling.

In this paper, to avoid such large memory requirement, a simple and easy 2D-FDTD analysis for indoor propagation model at 2.4 GHz band is made an attempt. Here the TM_z mode of the Yee's FDTD formulation (A. Taflove, *Computational Electrodynamics*, 2nd ed., Artech House, 2000) is utilized. A numerical experiment is done for a real indoor model, *i.e.* a 30×30 m floor space in the building of Niigata University. The analytical region includes four lecture rooms and one hallway. In this 30×30 m case, the 2D-FDTD does not require huge available memory size. While, by using the PC software, the simplified measurement of the signal strength in the wireless IEEE 802.11 system is executed along the hallway. In comparison between the numerical and the measured results, it is verified that very similar propagation tendency in the hallway region is observed, even though the reflection contributions from both the floor (lower) and the ceiling (upper) surfaces are not included in the simple 2D modeling. From some points of view, physical interpretation for this *strange tendency* of the propagation feature between them will be discussed.

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