NO-WAVE-EQUATION RADIOPROPAGATION MODELS: EXPERIENCES WITH THE PERCOLATION THEORY

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Abstract

The use of accurate radiopropagation models is of paramount importance for a large variety of problems. Among them, the study of electromagnetic (EM) urban area propagation is probably one of the most relevant, because of its importance in the design of reliable wireless communication networks. Several models are available indeed, with different characteristics. Apart the trivial free-space (FS) approximation, it can be worth mentioning empirical models such as the Okumura-based model (OK), or the semi-deterministic Walfisch-Ikegami model (WI), or fully-deterministic methods such as ray-tracing. All these models, resulting from a research effort starting several decades ago, are far from fulfilling all the requirements. Some models are especially devoted to manage with specific geographical or urban characteristics, some others are too CPU-time demanding, others deserve a strong tuning effort before ensuring reliable predictions.

As a matter of fact, new models must be experienced, based on new formulations. Among them, percolation theory is quite promising. The model is based on the assumption that EM urban propagation can be assimilated to a fluid flowing through a percolative lattice (Franceschetti, Marano and Palmieri, IEEE Trans. Ant. Prop., 47, 9, 1999). Consequently, a modelling technique can be set up, without using the typical EM wave equations. In this work, the percolative approach (PA) is compared with more standard techniques, so that its potential perspectives and limitations are discussed into details.

In PA, an urban area is considered as a lattice. The lattice can be statistically described by the probability *p* of a square to be empty (or full). The urban tissue can be identified by its "occupancy" degree *q=1-p*. A monochromatic EM wave is assumed to impinge with a certain angle θ on the upper bound of the p-lattice: by combining the theory of geometrical optics and Markov chain theory the ray power loss after the n-th reflection can be predicted. Consequently, once the average behaviour of EM propagation has been investigated for the ensemble of possible p-lattices, with given p and θ, the probabilistic characterization of propagation is achieved.

The implementation of PA, as well as of other rough (FS) or sophisticated models, such as OK and WI models, allows a rigorous analysis of the PA performance. In Fig. 1 some results are proposed, demonstrating that the PA has a similar accuracy with respect to well renown models (OK and WI). Several other data also demonstrate the same conclusion.

Some current limitations must also be taken into account, such as the difficult management of wide-band sources, and the very relevant computational effort required to solve real three-dimensional problems. Nonetheless, the approach is quite promising, and the previous problems are challenging tasks for the immediate future.

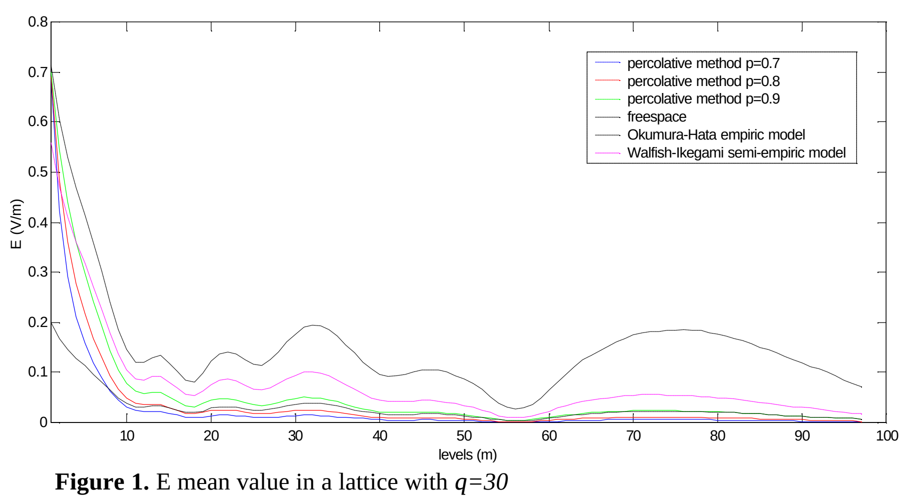

Figure 1. E mean value in a lattice with *q=30*