4-month internship for Master 2

Analytical model for realistic near-ground dipole antennas

Application to wireless sensor networks

Context:

Recently great attention has been drawn to sensor networks in which antennas are located close to the ground or are buried into it. In most applications the near-ground or underground sensor network is supposed to collect information for which the proximity to the interface or the immersion of the sensor into the lossy medium is required. Different application examples can be mentioned such as near-ground WSN for environmental monitoring (Fig. 1) or UWSN for precision agriculture (Fig. 2).

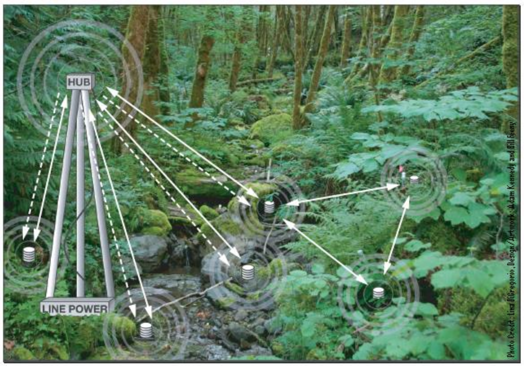

Fig 1. Near-ground WSN, Environmental surveillance FEEL project, Oregon State University

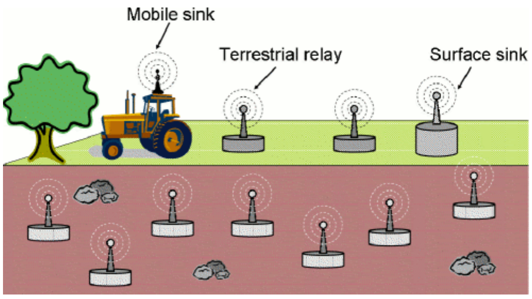

Fig 2. Underground WSN, Precision agriculture Broadband Wireless Networking Lab, Gatech, USA

This internship aims to contribute to the radio channel modelling in near-ground sensor networks where the close environment of antennas, near the ground, must be carefully taken into account. Otherwise, the inaccuracy of the model leads to erroneous estimation of the path loss, thus suboptimal network design and wasted energy [1]-[3].

Objectives of the internship:

This internship will be conducted in ESYCOM Laboratory and could be followed by a PhD thesis. The scientific work consists in two parts:

1. Understanding the existing model for elementary dipoles:

In [5]-[6], a theoretical model was developed for two elementary dipoles located near a lossy interface (Fig. 3). This deterministic model shows that potentially, under certain conditions defined by the model parameters, near-ground propagation has a lower attenuation and is therefore more favourable than a conventional free-space propagation (Fig. 4). The candidate will use the existing model in the beginning of the internship to realise different case tests in order to understand the impact of different parameters over the path loss, such as working frequency, electric properties of the interface and heights of the elementary dipoles.

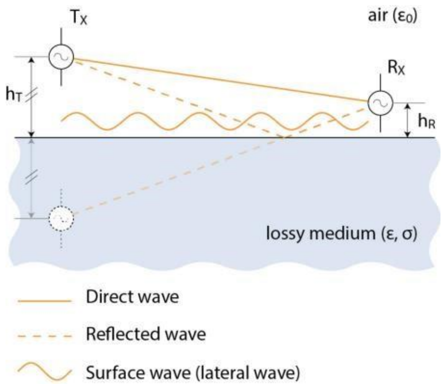

Fig 3. Different wave components for a near-ground wave propagation

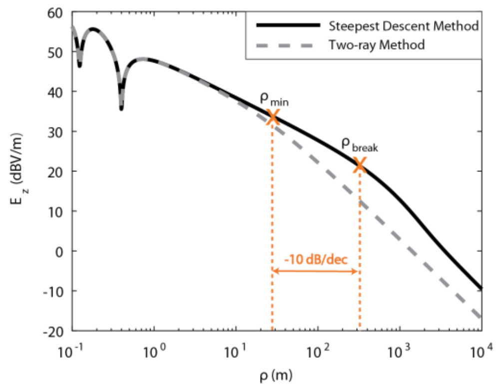

Fig 4. Field path loss for two vertical electrical dipoles above the ground. Interface made of a poor metal (σ = 5×103 S/m), f = 8.2 GHz, h_T = 10 cm, h_R = 10 cm, ρ_{min} = 21 m, ρ_{break} = 128 m

2. Extension of the existing model to realistic dipole antennas:

The second part of the internship concerns the extension of the theoretical model for elementary dipoles ($\ell << 50\lambda$) to realistic dipoles antennas ($\ell \cong \lambda/2$). This part can be accomplished in the first step for a thin dipole (known current distribution) by decomposing the realistic antenna into a series of elementary dipoles. The total radiated electric field is thus calculated by integrating the radiated elementary field along the dipoles. The objective is to quantify the impact of the realistic dipole antenna over the lower path loss observed in the case of the elementary dipoles.

Candidate's profile:

- Solid knowledge in electromagnetics and applied mathematics
- Very high scientific rigour and strong theoretical abstraction
- Autonomy in computer programming

Supervising group:

Supervisors: Shermila Mostarshedi, Associate Professor, ESYCOM/UGE
Benoit Poussot, Associate Professor, ESYCOM/UGE

Application procedure:

The application file should include CV, statement of purpose and all academic transcripts may be addressed by email to Benoit Poussot (benoit.poussot@univ-eiffel.fr) and to Shermila Mostarshedi (shermila.mostarshedi@univ-eiffel.fr).

References:

[1] S. Sangodoyin, S. Niranjayan, and A. F. Molisch, "A Measurement-Based Model for Outdoor Near-Ground Ultrawideband Channels," *IEEE Trans. Antennas Propag.*, vol. 64, no. 2, pp. 740–751, 2016.

[2] W. Tang, X. Ma, J. Wei, & A. Wang, "Measurement and Analysis of Near-Ground Propagation Models under Different Terrains for Wireless Sensor Networks," *Sensors*, vol. 19, no. 8, 2019.

[3] S. Duan, R. Su, C. Xu, Y. Chen, & J. He, "Ultra-Wideband Radio Channel Characteristics for Near-ground Swarm Robots Communication," *IEEE Transactions on Wireless Communications*, 2020.

[4] M. H. B. Cardoso, "Modélisation de la propagation des ondes électromagnétiques près du sol: application aux réseaux sans fil," PhD, Université Paris-Est, 2017.

[5] M. H. B. Cardoso, S. Mostarshedi, G. Baudoin, and J.-M. Laheurte, "Analytical Expressions of Critical Distances for Near-Ground Propagation," *IEEE Trans. Antennas Propag.*, vol. 66, no. 5, pp. 2482–2493, 2018.