Antennas and electromagnetic simulators for demanding wireless applications in complex environments

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Antennas for demanding applications (wireless sensors)

- Antennas need to be extremely versatile:
  - small, adaptive, low-cost, mobile, "smart"
- Those demands are almost always opposed to optimal conditions for antenna performance
- Antenna specifications are pushed close to fundamental physical limits
Antennas for WSN operate in unfavorable electromagnetic environments

- Inside or close to lossy media (human body, soil, water, ...)
- Geometrically complex and highly inhomogeneous media
- Stochastic (unpredictable) environments:
  - movement of the object/body, influence of surrounding bodies, walls, metallic objects..
Antenna design

- Modern and future antennas have to be designed by the synergy of
  - strong **fundamental knowledge** and
  - powerful **software tools**
Our software for antenna design

- **Wipl-D Microwave**: MTT simulator
- **Linpar, Matpar, Linres, Multlin**: multiconductor transmission lines (incl. in *Microwave Office*)
- **Wipl-D Pro**: 3D EM simulator and optimizer
- **Awas**: analysis of wire antennas and scatterers
- **E3D**: 3D electrostatic simulator
- **SchematicSolver**: symbolic system simulation
Antennas above and in real ground and layered media

- Accurate method
- Reduces memory demands and computing time more than 10x
- Extension of the method to layered media (in near future)
- Implemented in AWAS and WIPL-D Pro
- Application to WSN: sensors in ground, water, for agriculture, meteorology, geology...

- GENERAL SINGULARITY EXTRACTION TECHNIQUE FOR REFLECTED SOMMERFELD INTEGRALS,
Interaction between mobile handsets and the human head: simulation and measurements
Mobile handset radiation diagram
Absorbed power and radiation efficiency

\[ \eta \text{ [\%]} \]

- \( \eta \text{ (theoretical)} \)
- \( \eta \text{ (measured)} \)
- \( e \text{ (theoretical)} \)

Distance [mm]
Partners:

Mobile communications Lab
NCSR “DEMOKRITOS”
Institute of Informatics & Telecommunications
www.iit.demokritos.gr

Electromagnetic Group
University of Belgrade
Faculty of Electrical Engineering
www.etf.bg.ac.yu


and several conference papers
Antennas on and inside human body for wireless body-area network (WBAN)

- WIPL-D Pro simulations

  - Chest: sim. dipole and L-dipole on the skin
  - Belt: symmetrical dipole close to the body
Antennas on and inside human body for wireless body-area network (WBAN)

two chest implanted sim. dipoles (about 0.5 cm deep)
Antennas on and inside human body for wireless body-area network (WBAN)

- WIPL-D Pro simulations

back: sim. dipole and L-dipole on the skin
Results for transfer between antennas (Propagation path Gain, $S$ parameters)

- frequency $f = 2.45$ GHz, $\text{PG [dB]}$ (<10 min, single core PC, 2.6 GHz)

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</table>
Simulation models can be much more realistic and detailed.

Models in WIPL-D Pro
Conclusion: Possible design procedure for WSN antennas

- Antenna design, placement and propagation
- Extensive numerical simulations and optimization
- Avoid accurate lab. measurements because:
  - they are complicated, time consuming, expensive, in unrealistic “ideal” environment
- Test prototypes in real conditions
- Iterate if necessary
- Perfect for SME (WIPL-D company is SME)
Thank you