Antenna Height Compensation for an Indoor to Outdoor Channel model based on a 2D Finite Difference Model

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Outline

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- Combined Model
- MR-FDPF
- IRLA
- 2D Results
- Taking into account antenna height
- Conclusions, perspectives

Introduction

- In the very near future: base stations deployed directly inside buildings (femto/pico cells)
- Such elements have impact on outdoor cells (macrocells)
- Indoor to Outdoor propagation models are more and more important to study interference.

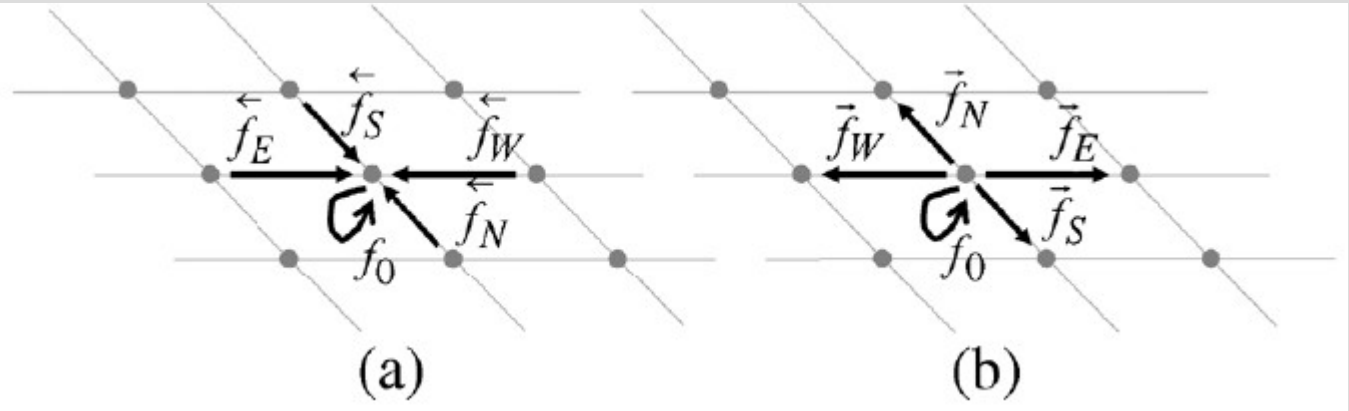
Accurate methods for propagation

- 2 main kinds of “deterministic” models for wireless network planning:
- Ray Optical models (e.g., ray tracing)
  - Descartes Laws
  - Reflections and diffractions on the obstacles
  - GTD/UTD
- Finite Difference Based (e.g., FDTD)
  - Maxwell's equations
  - Discrete grid

Why a combined model?

- Indoors:
  - Many obstacles (less open space)
  - Smaller area
  - 2D is fine (multi floor) ->Finite difference
- Outdoors
  - More open space
  - Larger environment
  - 3D is needed ->ray optic based based

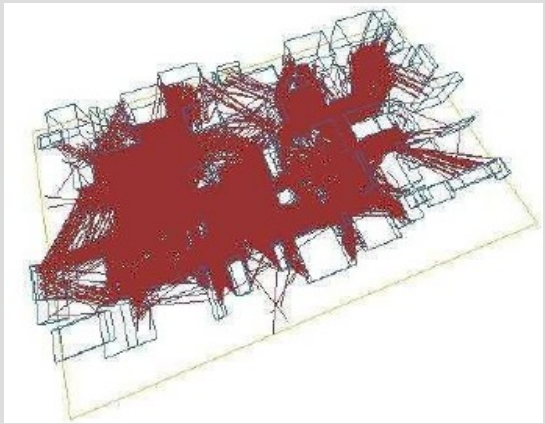
Finite difference method: MR-FDPF



- ParFlow (Partial Flows)
- Frequency domain implementation (narrowband)
- Multi-resolution approach
- MR-FDPF [1]

[1] J-M. Gorce, K. Jaffres-Runser, and G. de la Roche. Deterministic Approach for Fast Simulations of Indoor Radio Wave Propagation. IEEE Transactions on Antennas and Propagation, 55:938–942, March 2007

Geometric method: IRLA



- Intelligent Ray Launching [2]
- Based on *cube* approach
- GTD
- Use of parallel processes

[2] Z. Lai, N. Bessis, P. Kuonen, G. de la Roche, J. Zhang, and G. Clapworthy. A Performance Evaluation of a Grid-enabled Object-Oriented Parallel Outdoor Ray Launching for Wireless Network Coverage Prediction. In Fifth International Conference on Wireless and Mobile Communications, Cannes, France, August 2009.

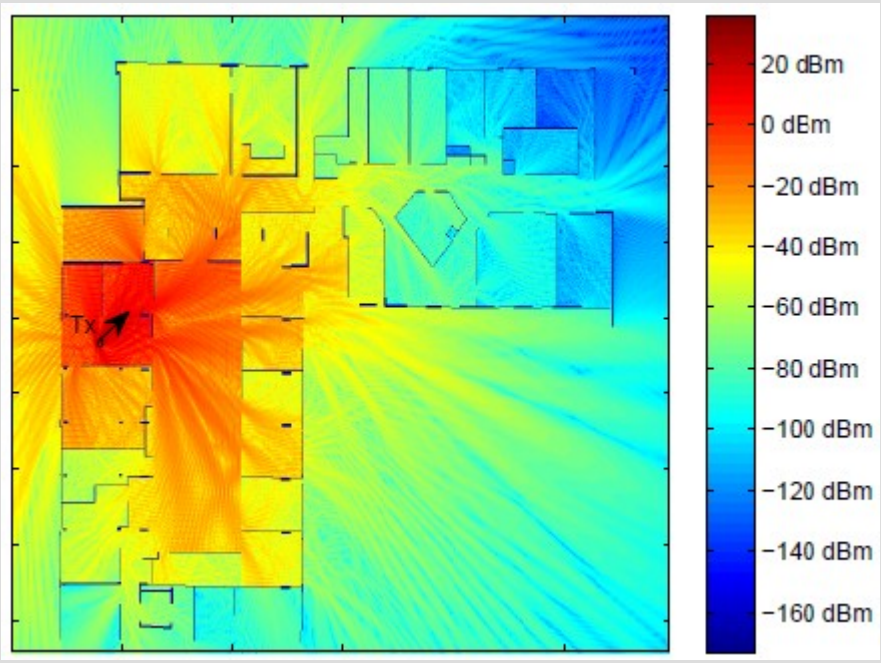
Link between the models?

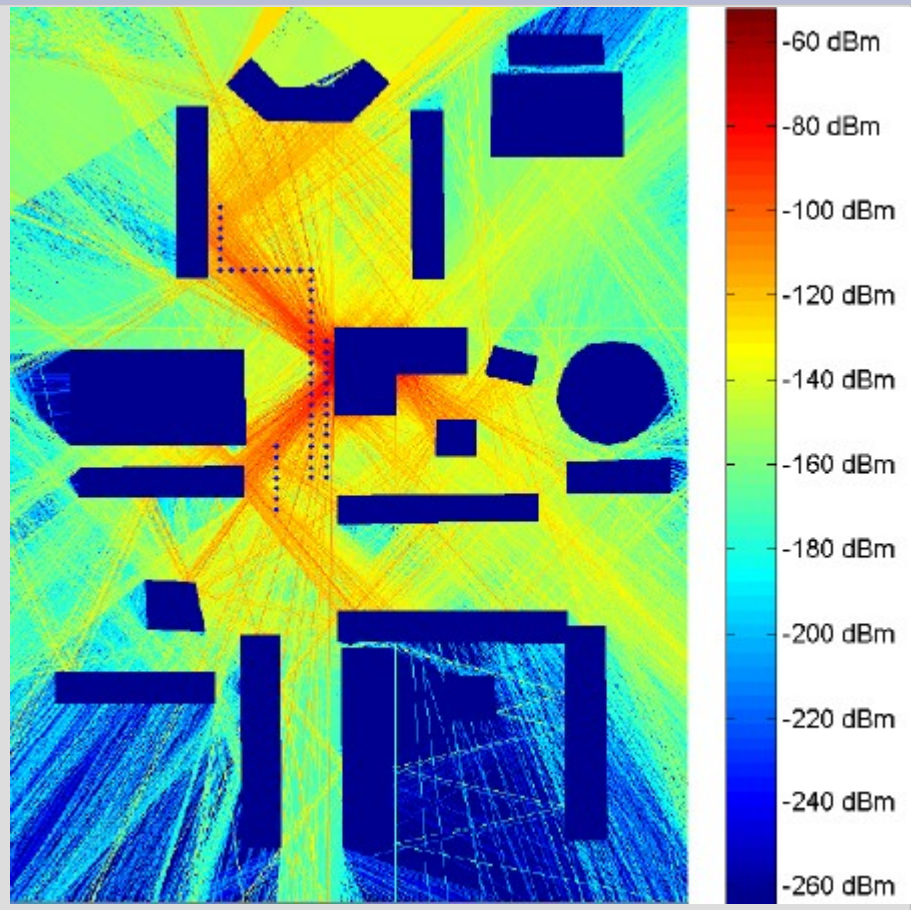
- MR-FDPF provide gains and phases on borders of the building (every 5 cm)
- The main rays are computed with SAGE (space-alternating generalized expectation-maximization algorithm)
- Using 8 pixels provide sufficient results.
- The new equivalen rays are launched outdoors using IRLA model

2D example

- The scenario: CITI building in the university of Lyon campus.
- 2.5D database of buildings (googlemaps)
- 3D database of CITI building (Architect dxf files)

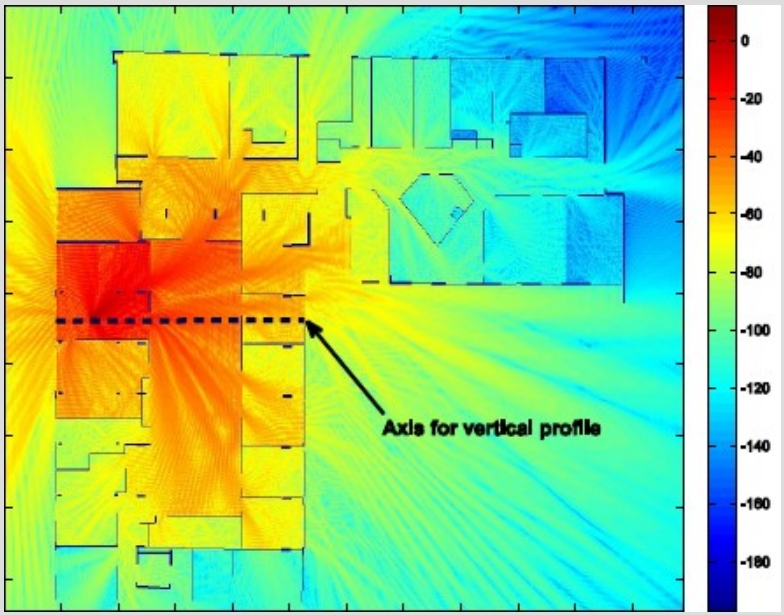
Results





- RMSE = 4dB indoors
- MR-FDPF Simulation time < 1min
- IRLA simulation time < 1min

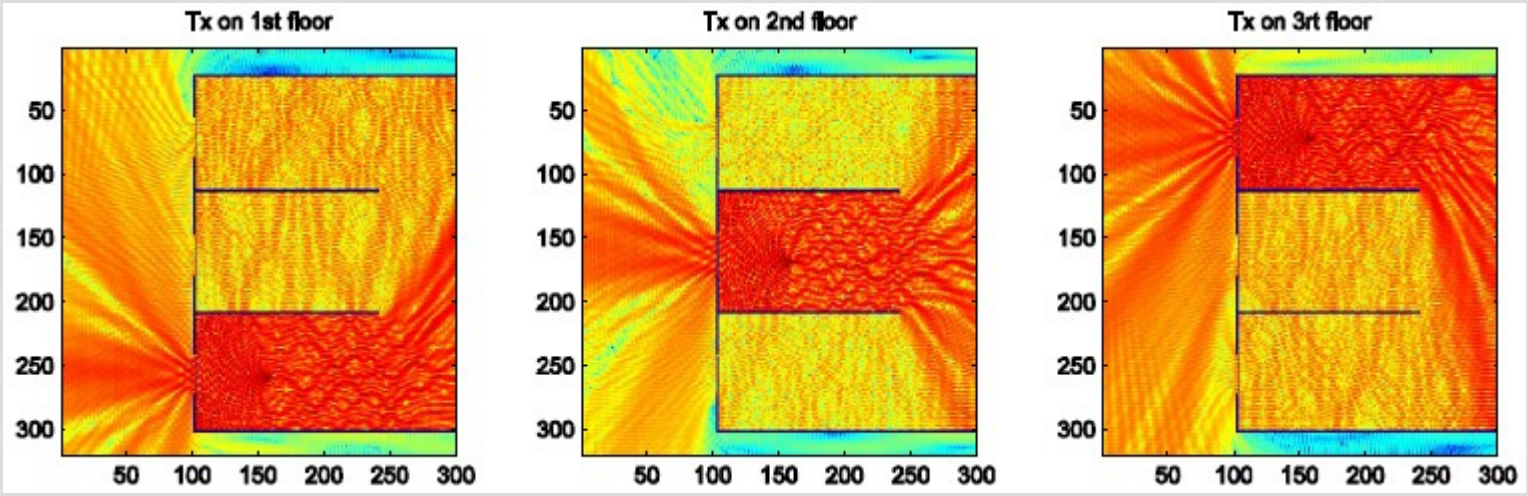
Taking into account for height of antenna



- Horizontal plane simulation is performed at height *h*
- Vertical plane simulation is computed (profile)

- The previous technique is used to compute IRLA ray at height *h*
- For other heights we adapt gains based on the vertical profile

Taking into account for height of antenna



- This technique is efficient if the vertical profile is similar on the whole building
- New measurements are needed to calibrate this technique

Conclusion

- More measurements are needed.
- Mast is needed to test different elevations.
- Advantage of the combined model is:
  - It would have been to memory/time consuming to perform simulation for the whole scenario using MR-FDPF
  - Only require accurate knowledge of 1 building
- Disadvantage is:
  - When going to 3D, what we win with our approach we loose it due to the SAGE...

References

[1] G. de la Roche, P. Flipo, Z. Lai, G. Villemaud, J. Zhang, and J-M. Gorce. Implementation and Validation of a New Combined Model for Outdoor to Indoor Radio Coverage Predictions. EURASIP Journal on Wireless Communications and Networking, Article ID 215352, 2010.

[2] D. Umansky, G. de la Roche, Z. Lai, G. Villemaud, J-M. Gorce, and J. Zhang. A New Deterministic Hybrid Model for Indoor-to-Outdoor Radio Coverage Prediction. In European Conference on Antennas and Propagation (EuCAP 2011), Rome, Italy, April 2011.

[3] A. Valcarce, G. de la Roche, L. Nagy, J-F. Wagen, and J-M. Gorce. Finite Difference Methods: A New Trend in Propagation Prediction. IEEE Vehicular Technology Magazine, Special issue on Trends in Mobile Radio Channels, June 2011.

[4] FP7 Project IPLAN on Indoor Wireless Network Planning

Thanks !