



An Introduction to CWiND and Some Potential Collaboration Topics

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Outline

- A brief introduction to the Dept. of Computer Science and Technology (DCST), University of Bedfordshire
- An introduction to CWiND
 - Members
 - History
 - Funding
 - Publications
- Collaboration areas
 - FDD and TDD-LTE simulation platform
 - Femtocells
 - Indoor – outdoor propagation

Introduction to the Dept. of **Computer Science and Technology (DCST)**

Introduction to DCST

- There are some **30 academic staff** (inclusive of 6 professors) at DCST, University of Bedfordshire
- There are some **60 Research Fellows and PhD students**.
- The research at DCST is divided into three groups:
 - CCGV (**C**entre for **C**omputer **G**raphics and **V**isualisation)
 - CREDIT (**C**entre for **R**Esearch in **D**istributed **T**echnologies)
 - CWiND (**C**entre for **W**ireless **N**etwork **D**esign)

Group 1 - CCGV

- CCGV (**C**entre for **C**omputer **G**raphics and **V**isualisation) mainly focuses on **Computer graphics and visualisation**.
- 2 professors (Prof. Gordon Clapworthy, Prof. Feng Dong) and some lecturers.
- CCGV has hosted **numerous research projects** funded by the EU FP5/FP6/FP7 and the EPSRC.
 - In the first four calls of FP7 ICT programme, the group has been awarded at least 9 projects. Won three projects in each of call 1, 3 and 4.
- There are currently some **20 Research Fellows** at CCGV.
- It is the key initiator of the **Living Human Program** (one of the challenges in FP7 ICT program).
- The group has very high influence in their area at the European level, e.g.,
 - Prof. Gordon Clapworthy, the group head, was invited by the European Commission (EC) to give a talk on future directions of ICT program, in May 2009.
- CCGV has collaboration with the studio that produced **“The Lord of Rings”** (through an EPSRC-funded project).
- Their work is used in an **Oscar** nominated film.

Group 2 - CREDIT

- CREDIT (**C**entre for **RE**search in **D**istributed Technologies)
- 3 professors (Profs. Carsten Maple, Yong Yue, Song Yan) and some lecturers
- Research covers **distributed and parallel computing** and **information security** etc
- CREDIT has hosted **dozens of research projects** funded by various sources such as the EPSRC, Leverhulme, the Royal Society, the Nuffield Foundation, JISC, ...
- There are currently some 15 Researchers.

Group 2 - CREDIT

- Prof. Song Yan is a Visiting Professor at **Harvard University** (USA) and **MIT** (USA), sponsored by the Royal Society.
- One of his monographs in information security is used as a textbook at the Computer Science Dept. of MIT.
 - Described by a Turing award winner as beautifully written.
- Prof. Yan is the organiser of the **Distinguished Lecture** series at DCST, including
 - Experts in information security from the UK, e.g., The Royal Holloway, University of London
 - Two **Turing award winners** from MIT, etc.
- Prof. Yan has good personal relationships with some of the greatest mathematicians in the world.

Today's focus is CWiND



Introduction to CWiND

Introduction to CWiND - Missions

- Missions:
 - To develop novel approaches that will solve **RAN** (Radio Access Network) **planning and optimisation** problems of real industrial interests;
 - To become one of the best-funded, one of the best-known, and the leading research group in wireless network planning and optimisation in academia in the world.

Introduction to CWiND - Members

- CWiND is composed of:
 - 5 academic staff: **one professor** and 4 Senior Lecturers/Lecturers. Apart from me, all have PhD degrees in telecom/networking from reputable universities.
 - 3 associated academic staff in high performance computing and optimisation/Operations Research
 - 20-25 postdoctoral Research Fellows and PhD students.
- One of the largest and leading research groups in **radio network planning and optimisation** in Europe.
- A world leader in indoor wireless network design and femtocell research.

Introduction to CWiND - Members

- At least 10 CWiND members worked with Ericsson, Nokia, Siemens, Nortel, Vodafone, Telefnornica R&D, Intel, Bynear, China Telecom and Aircom before joining the group.
- In particular, a number of CWiND members had been involved in developing the market leading **commercial radio network planning and optimisation tools**.

Introduction to CWiND - History

- CWiND was formed in 2006.
- Professor **Jie Zhang** is the founding Director of CWiND.
- No research in communications existed at DCST before 2003.
- CWiND is a new research group.

Introduction to CWiND - History

- Dr Zhang joined the DCST, University of Bedfordshire in 2002 after some 5-year postdoctoral research with UCL, Imperial College London and Oxford U..
- In 2003, he was awarded a Newly Appointed Lecturer Award by the Nuffield Foundation and a First Grant by the EPSRC, both on automatic 3G RAN planning and optimisation.
- In 2005 and 2006, he was awarded two single contractor FP6 projects worth €1.75m, which can support over 15 researchers.
- In 2007-2008, he was awarded further 8 projects worth over 2 million Euros (his share).
- Other CWiND members also won a number of research projects from the EPSRC and other sources.

Introduction to CWiND-Funding

- Since 2003, CWiND members have been awarded **over 20 research projects** (worth over £4.0 million to the group) by the EPSRC, the European Commission (FP6/FP7), the Nuffield Foundation and the university.
- In the next three years, there will be **at least 10 projects** (funding secured) running with **over £3.0 million** grant value to CWiND.
- These projects are centred on
 - **New radio propagation models**
 - **UMTS/HSPA/WiMAX/LTE simulation, planning and optimization (including self-optimisation)**
 - **Indoor radio network design**
 - **Combined indoor and outdoor wireless network design**
 - **Femtocells**

Introduction to CWiND-Publications

- Since 2008, each year, CWiND members publish 20-30 papers in prestigious journals and leading conferences in communications.
- For example, in 2009
 - **Book: “Femtocells – Technologies and Deployment”**, Wiley, Dec. 2009 or Jan. 2010.
 - **Over 10 Journal papers in**
 - IEEE JSAC (J. on Selected Areas on Comm.)
 - IEEE Trans. on Wireless Communications
 - IEEE Trans. on Vehicular Technology
 - IEEE Communications Magazine
 - IEEE Signal Processing Letters
 - IET Communications
 - ...

Introduction to CWiND-Commercialisation

- CWiND and its industrial partners are in the process of commercialising part of CWiND research, in particular, in **indoor wireless network design**.
- CWiND's industrial partner – *Ranplan Wireless Network Design Ltd.* is in the process of developing a radio network planning and optimisation tool that features **seamless integration of indoor and outdoor** wireless network planning and optimisation.
 - The first network planning/optimisation tool considering both indoor and outdoor at the design phase.
 - Compare various indoor solutions (DAS, picocells, femtocells) in terms of performance and cost.
 - Project management: e.g., output the number of network elements (antennas, splitters, attenuators, cables, ...) needed.
 - Features: Automatic 3D floor structure generation and visualisation, ...,
 - Ready for commercial offering at the beginning of 2010.

Introduction to CWiND-Commercialisation

- **“We choose to make one of the biggest spin-offs from the mobile communications sector in the UK academia, not because it is easy, but because it is hard.”**
- It is expected that in 3 years, the commercialisation activities from our spin-off(s) will support 10-20 full time researchers at CWiND and other research groups.

Overview of CWiND research

With assistance from Zhihua Lai, Alvaro Valcarce, Hui Song, Guillaume de la Roche, David Lopez, etc.

CWiND research

- Radio propagation
- Simulation of various RANs
- Automatic RAN planning and optimisation
- Femtocells

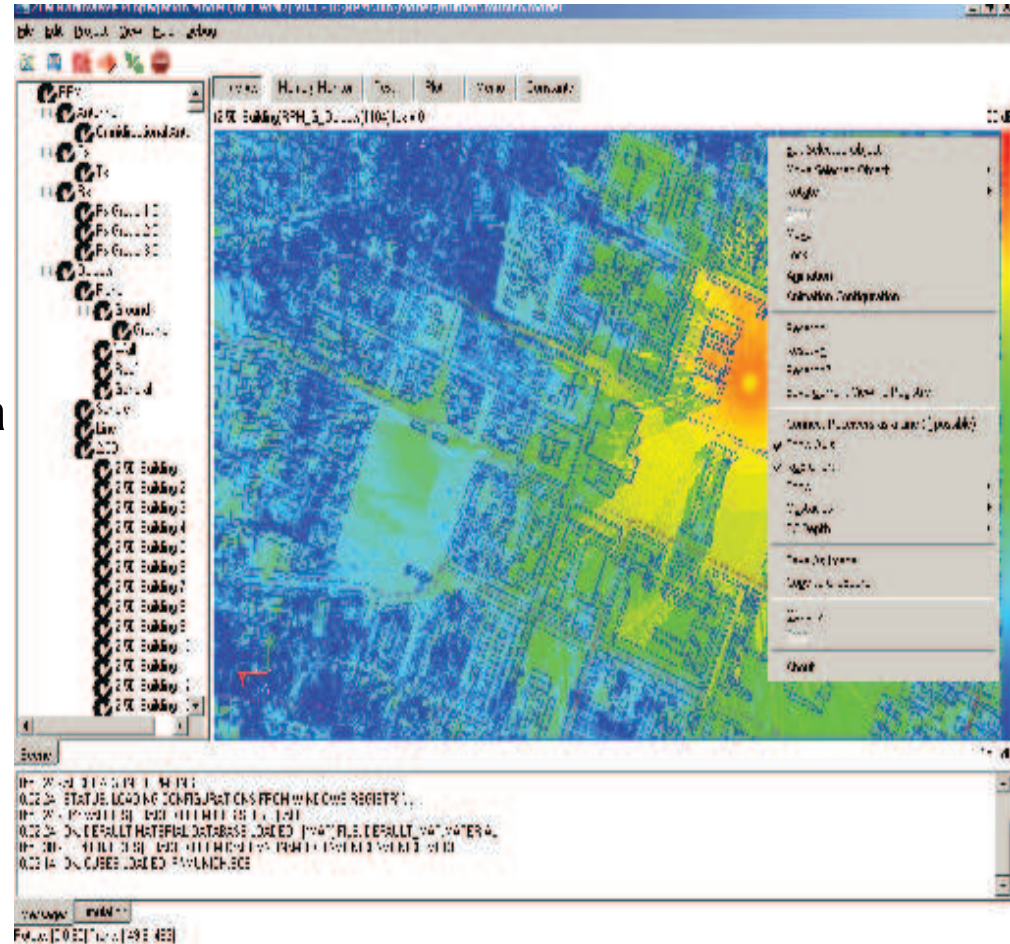
CWiND radio propagation engines

Propagation Models

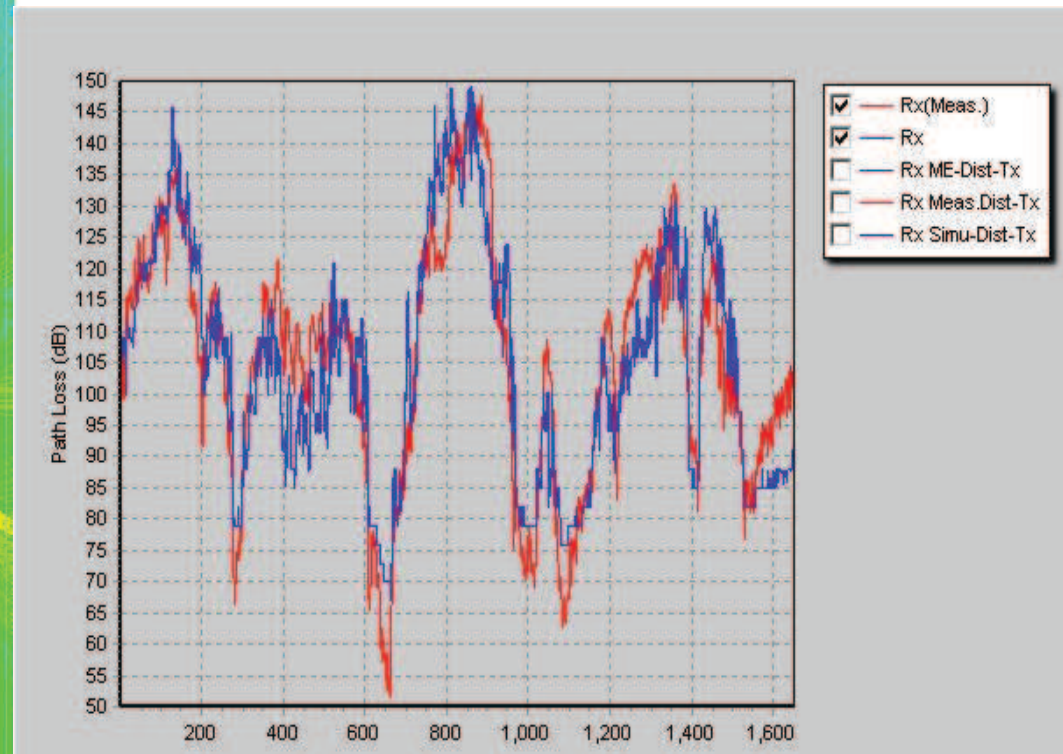
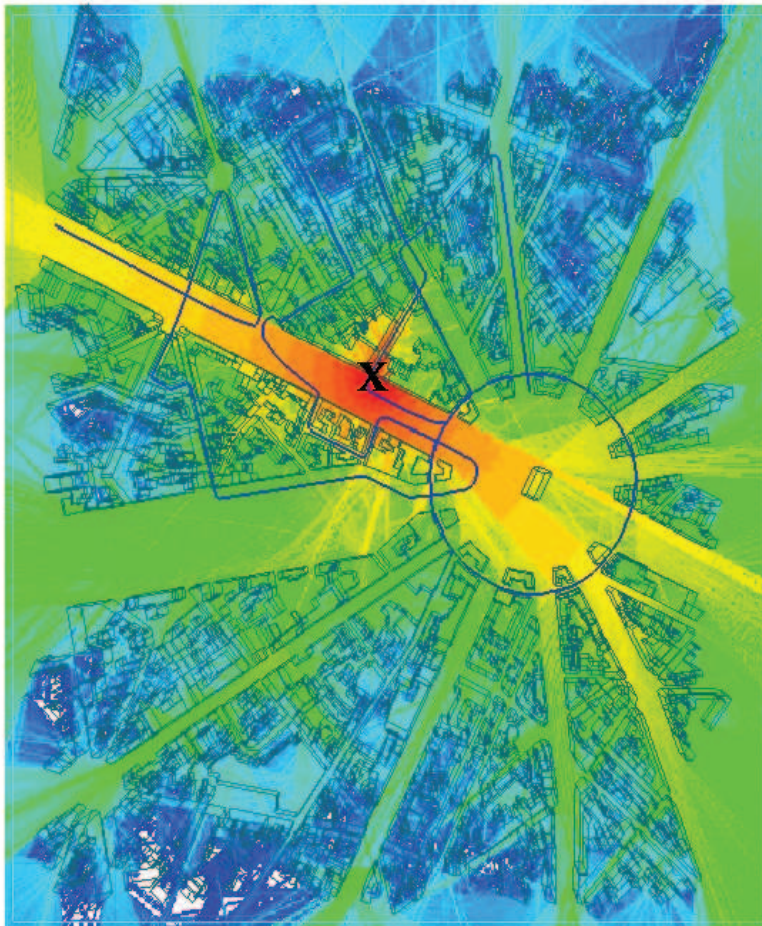
- We have developed **fast** and **accurate** 3D ray tracing/launching and FDTD etc propagation models.
- Our focus is on indoor <-> outdoor radio propagation for combined indoor-outdoor wireless network design and femtocell research.

Outdoor macrocell radio prediction using CWIND Radiowave tracer

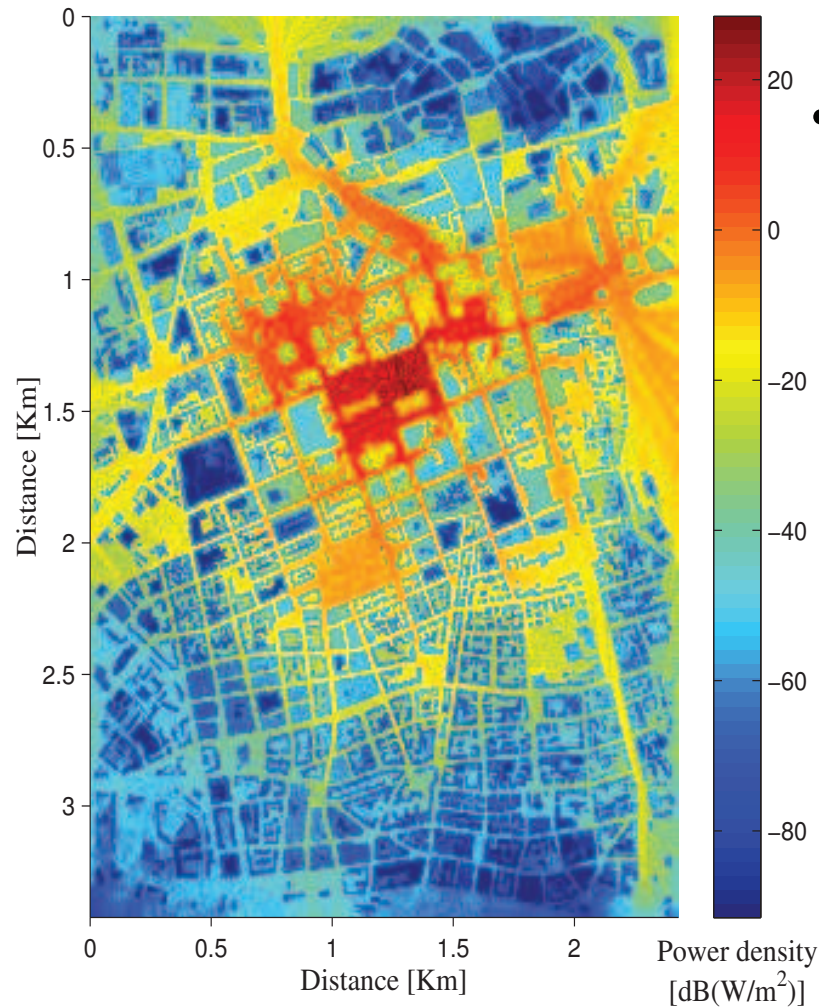
- CWIND Radiowave Tracer
 - Targeting accurate path loss and other parameters for a huge amount of receiver points (a few million) in a short amount of time
 - Easily-to-parallelize algorithm
 - Automatic calibration
 - More than 100K LOC, written in Object Pascal, C++ and Assembly.



Outdoor macrocell radio prediction using CWIND Radiowave tracer

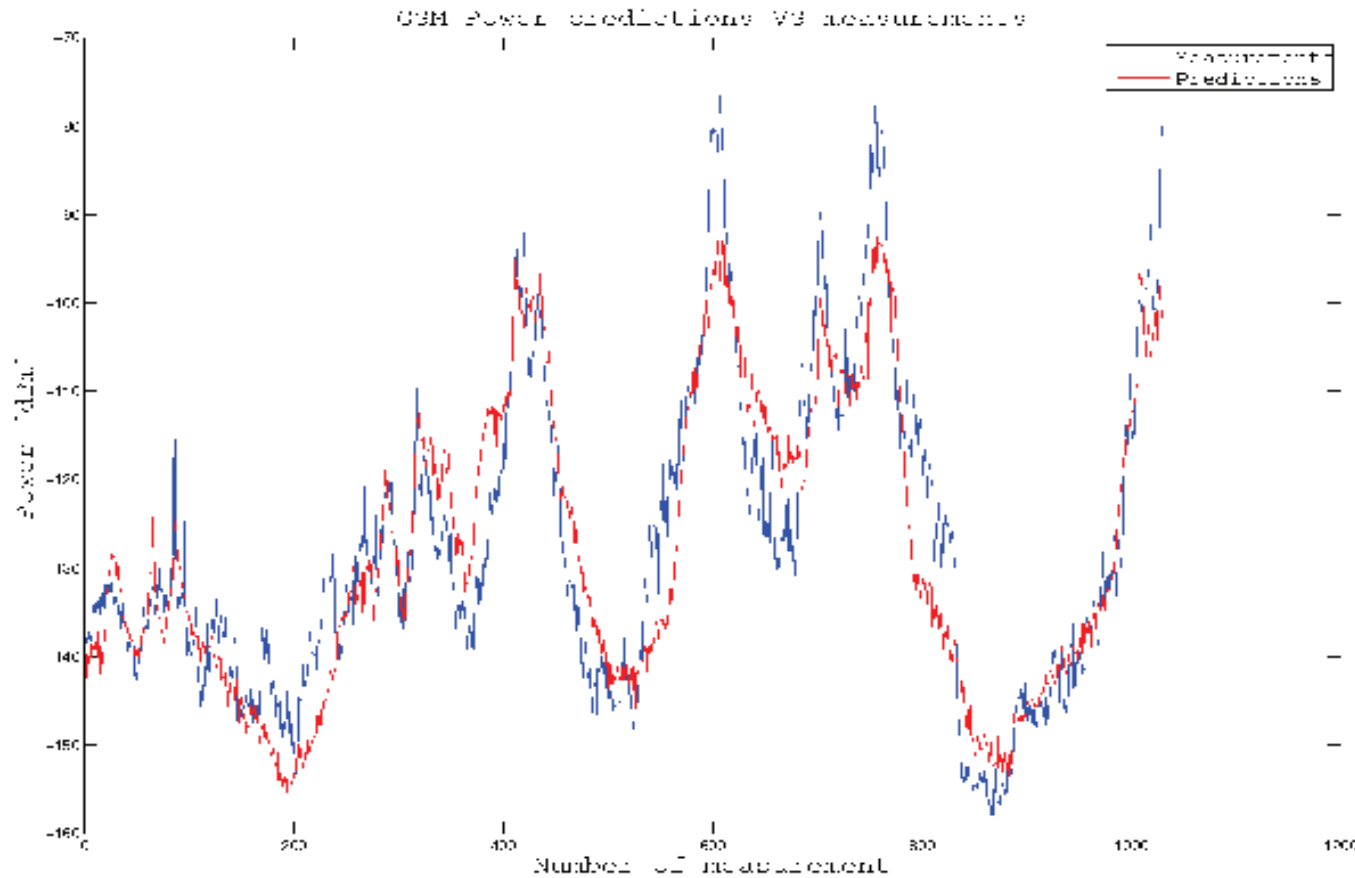


Outdoor macrocell radio propagation using FDTD

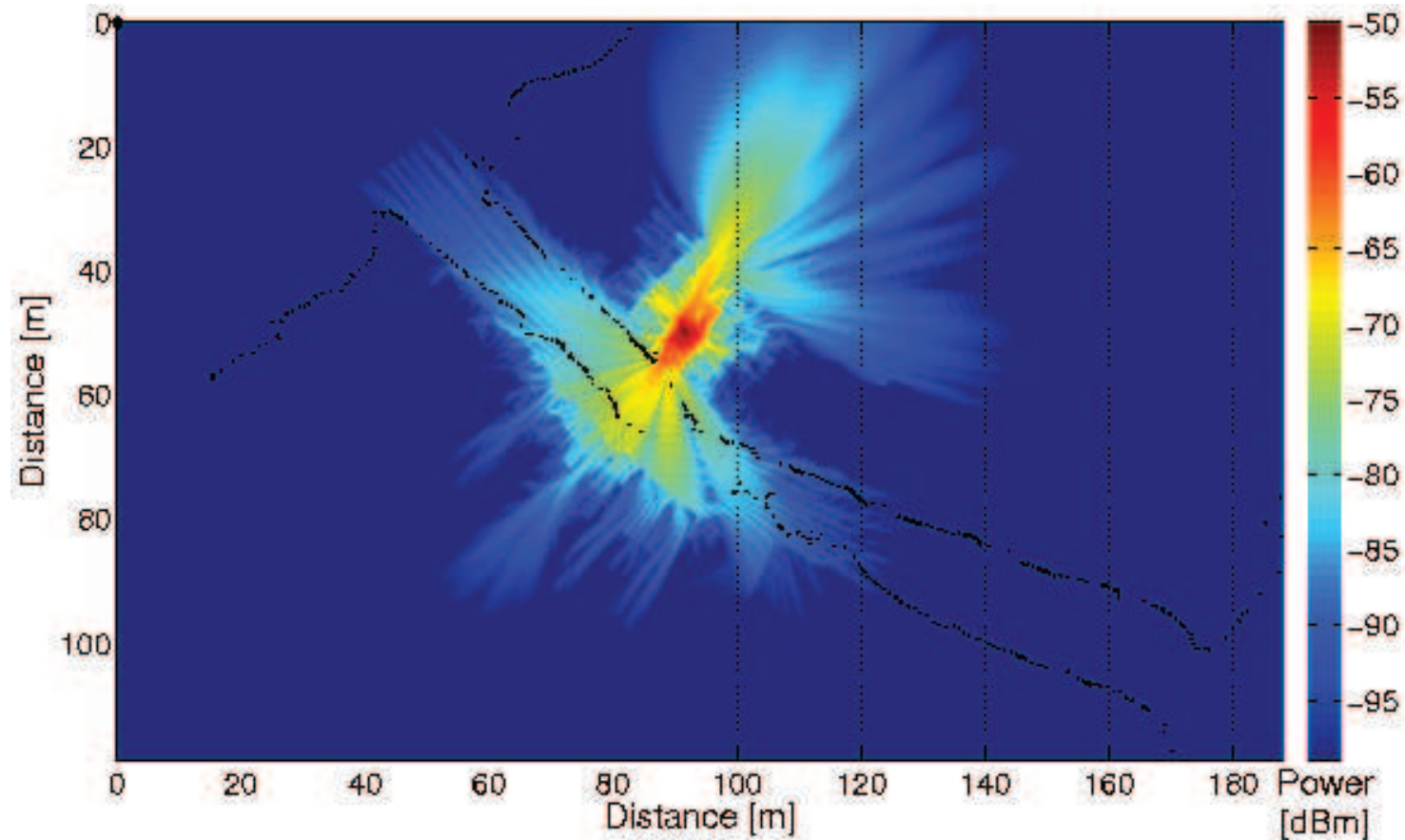


- Finite-Difference Time-Domain (FDTD)
 - Direct calculation of all reflections and diffractions
 - High accuracy due to Maxwellian formulation
 - Natural parallel structure
 - Time-Domain technique
 - Time information
 - Broadband simulation
 - Running time for an 8 Km² area (2 meters resolution): 8 seconds
 - RMSE=7.2 dB

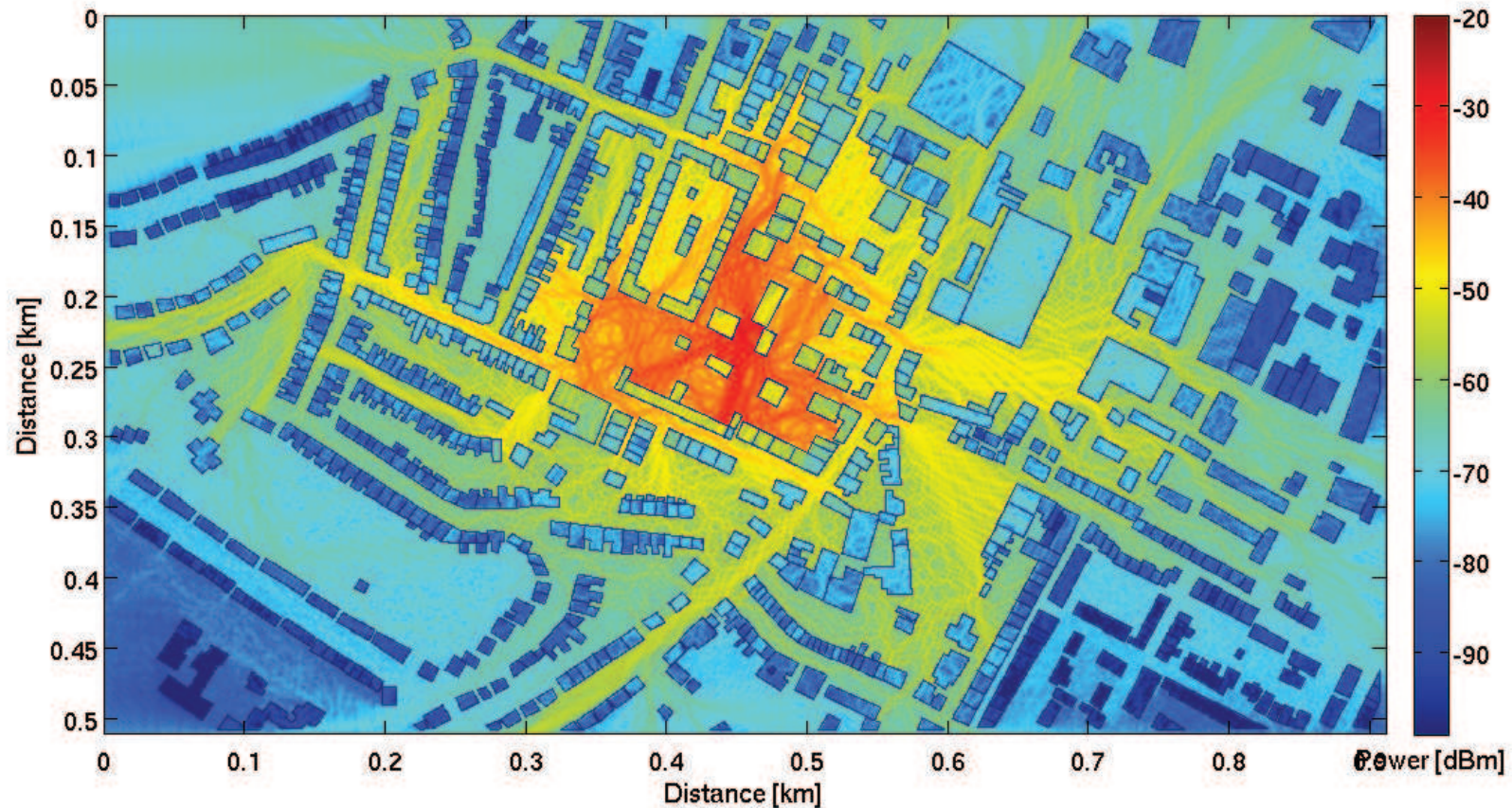
Macrocell measurements and prediction comparison. RMSE=7.2 dB



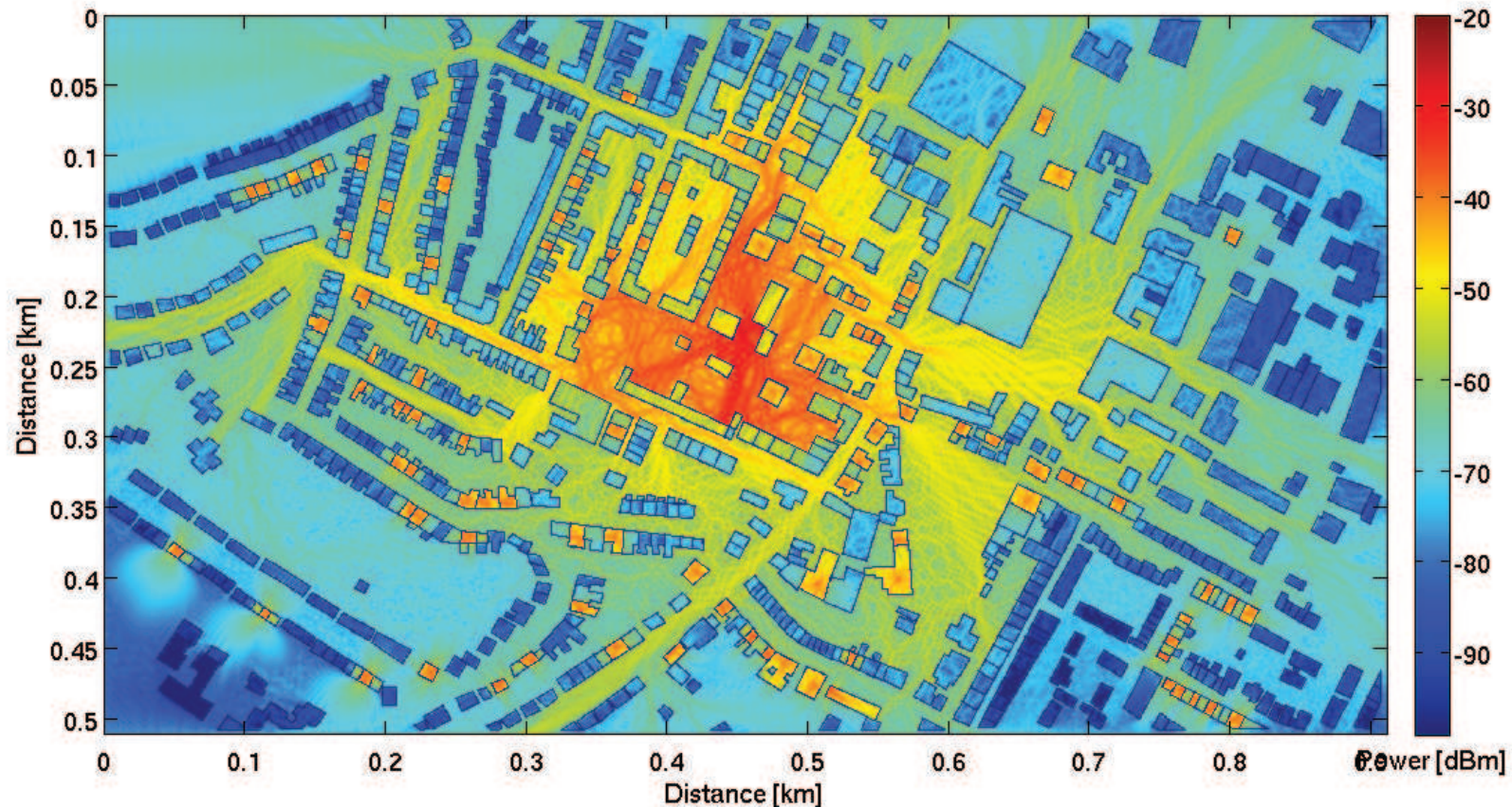
Femtocell (one) coverage prediction using FDTD



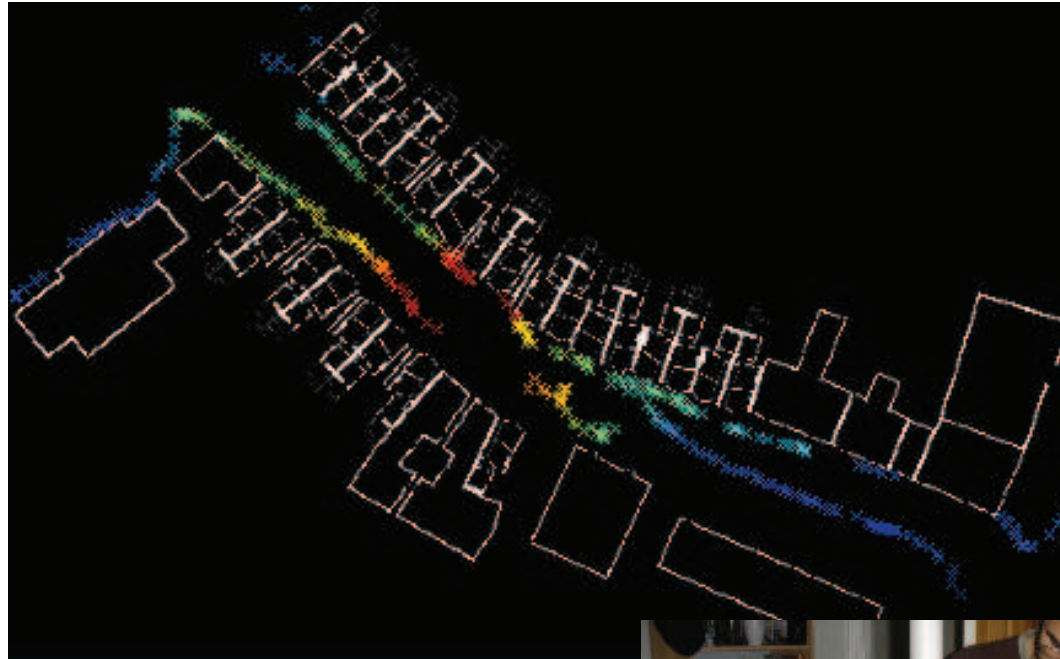
Coverage of macrocells using FDTD



Coverage of one macrocell and many femtocells using FDTD

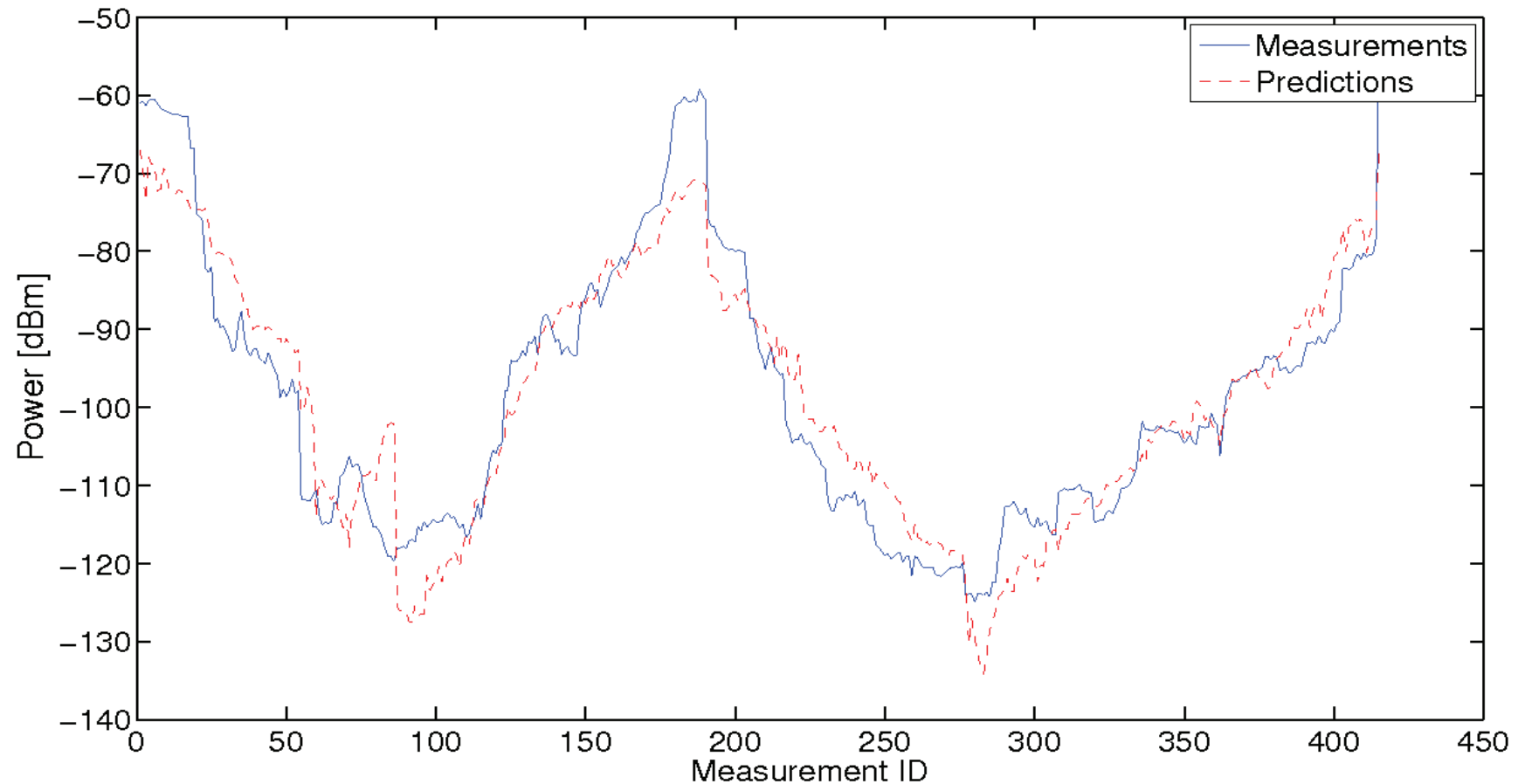


WiMAX Femtocell Measurement campaign



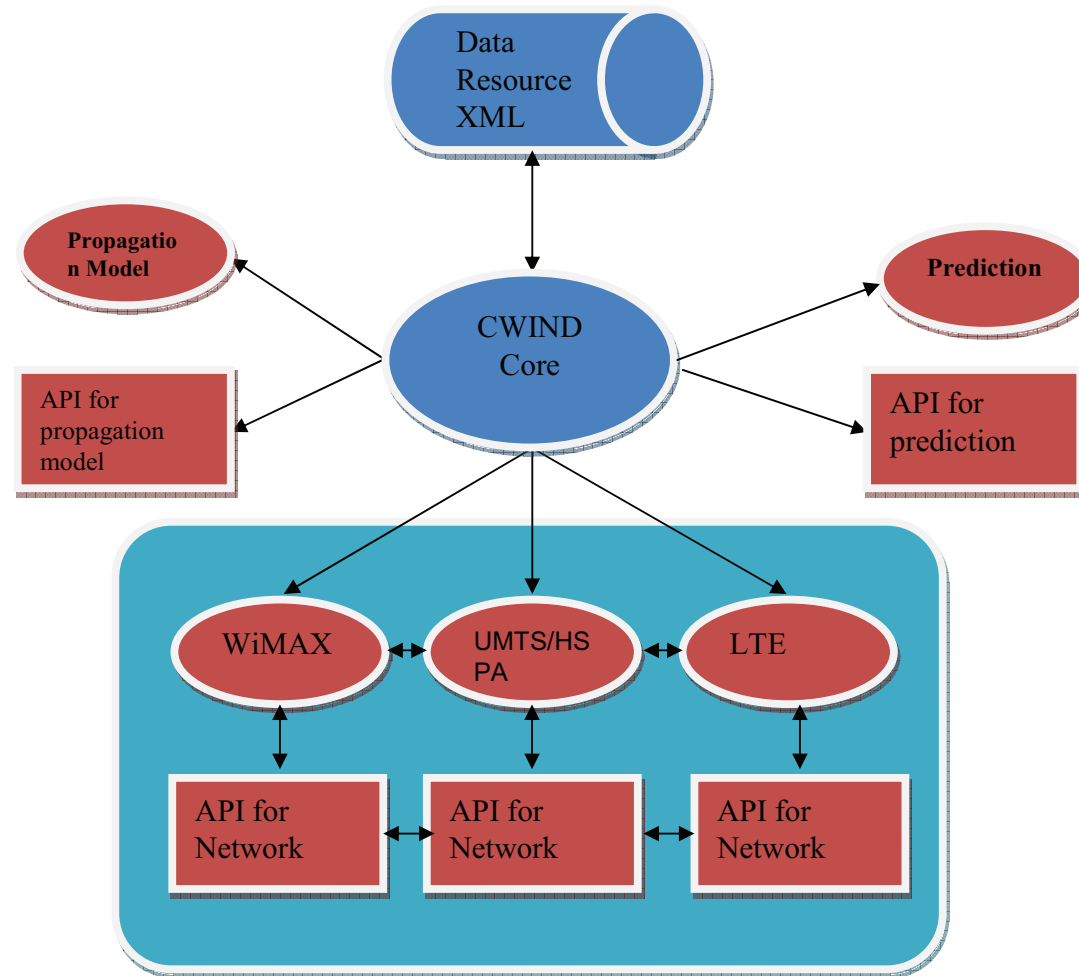
3.5 GHz

Femtocell Propagation and measurement comparaison (standard deviation = 6dB)



CWiND simulation platform

CWiND simulation platform

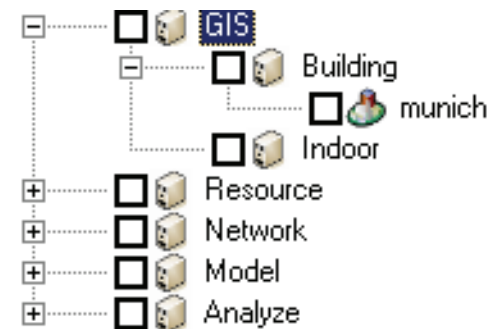


CWiND simulation platform

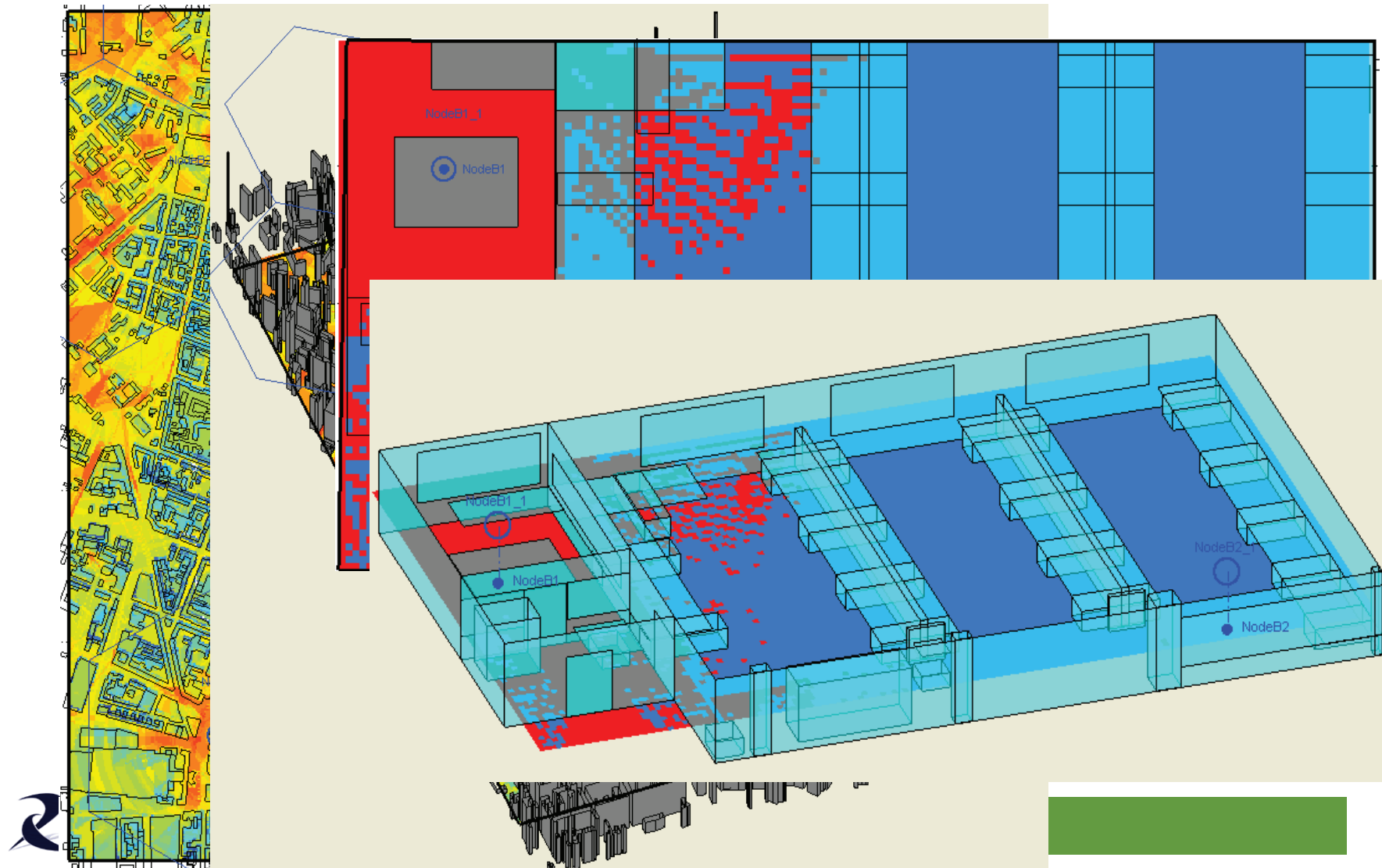
- Covers various wireless systems such as UMTS/HSPA, LTE (FDD) and WiMAX.
- Open architecture, extensible
- Some 250,000 line of codes (mainly in C++)
- GUI is developed using Matlab

GIS

- Full 3D GIS module
 - 3D View
 - 3D Operation
- Digital Map (currently, Building Database only)
 - Outdoor Building Data (2.5D)
 - Indoor Building Data (Full 3D)
 - CWiND format
 - .dxf (AutoCAD)

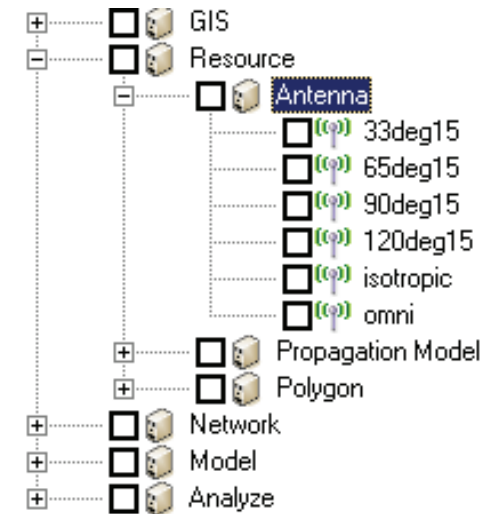
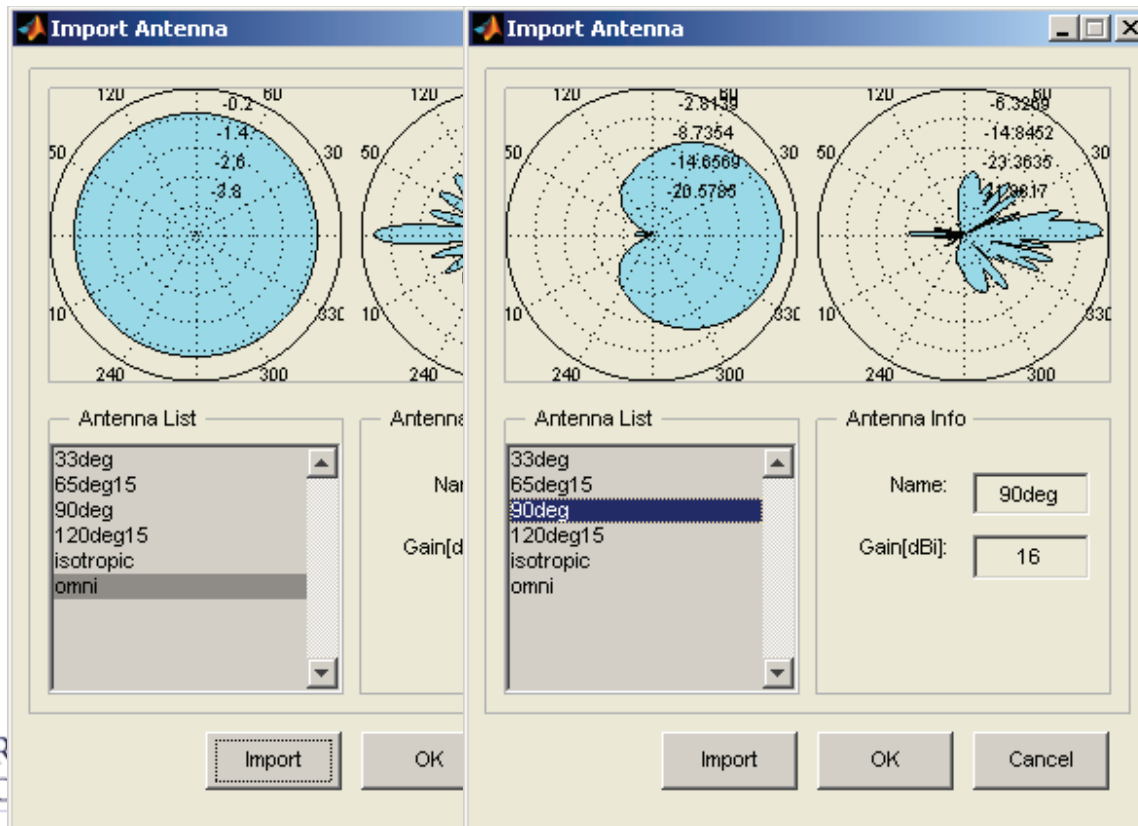


GIS



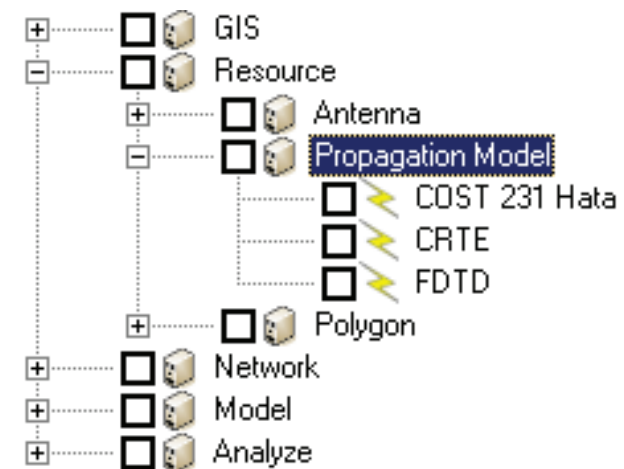
Antenna

- Support common formats
 - Nokia, Planet, Asset etc.



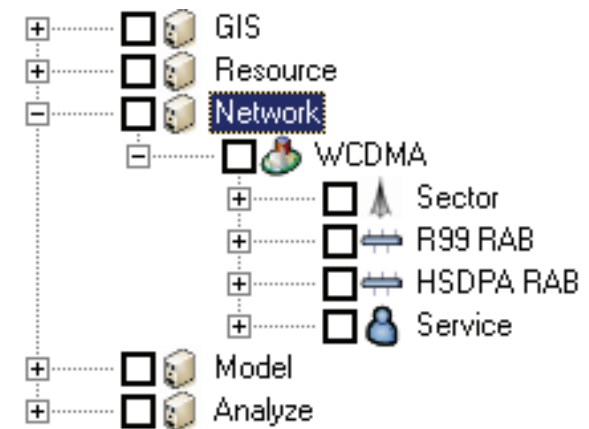
Propagation Model

- Pluggable API
 - COST 231 Hata
 - Ray Tracing/Launching Model
 - FDTD
 - Etc.



Networks

- Multiple Networks
 - WCDMA/HSDPA/LTE
 - WiMAX
- Multi-layer Network
 - Heterogeneous Network
 - LTE, WiMAX, WCDMA, WiFi...
 - Various Network Hierarchy
 - Macro Cell + Femto Cell

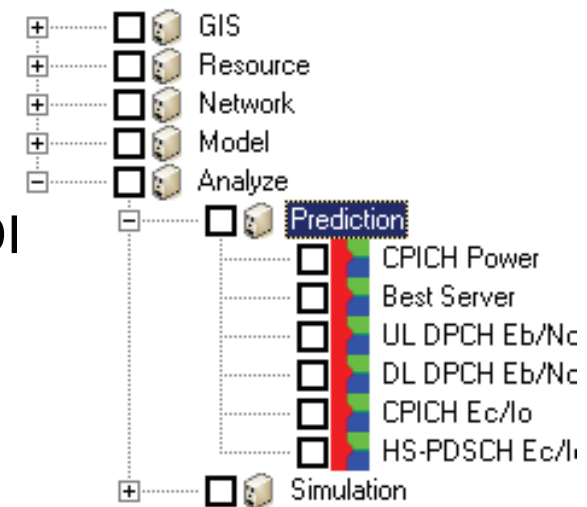


Analyses

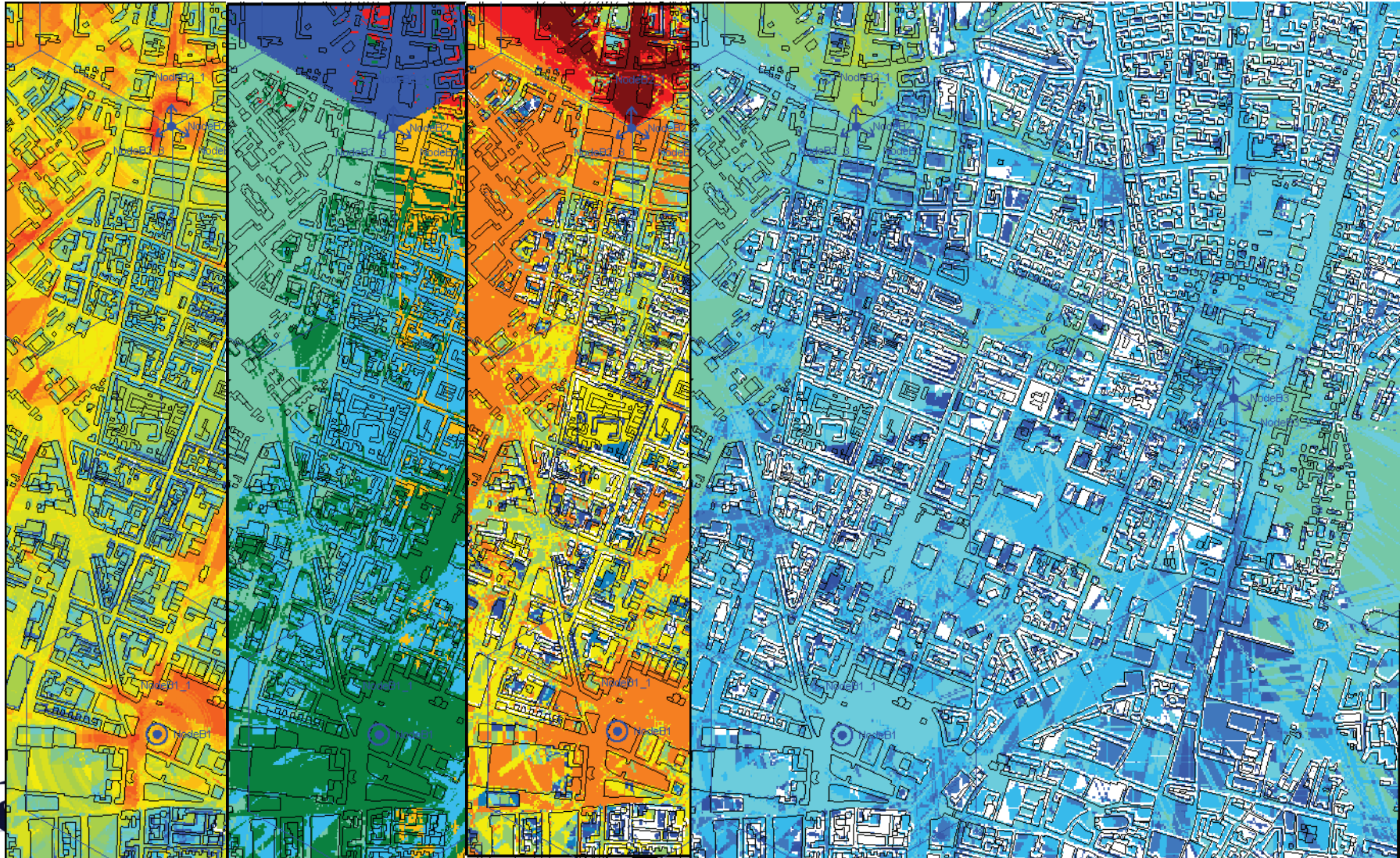
- Network Analysis
 - Performance Analysis (throughput, connection rate, quality)
 - Problem State (frequency collision, pilot pollution, etc.)
 - Optimization (AFP etc.)
- Analysis Modules
 - Prediction (including loading and non-loading related)
 - Simulation (including dynamic and static)
 - Measurement (DT, MM & OMCR in the future, post processing)
 - Optimization

Analyses (Prediction)

- Pluggable API
 - Loading Independent Prediction
 - RSCP (Pilot Power)
 - Best Server
 - Loading Dependent Prediction
 - CPICH Ec/Io
 - TCH Quality/Throughput
 - HSDPA Quality/Throughput

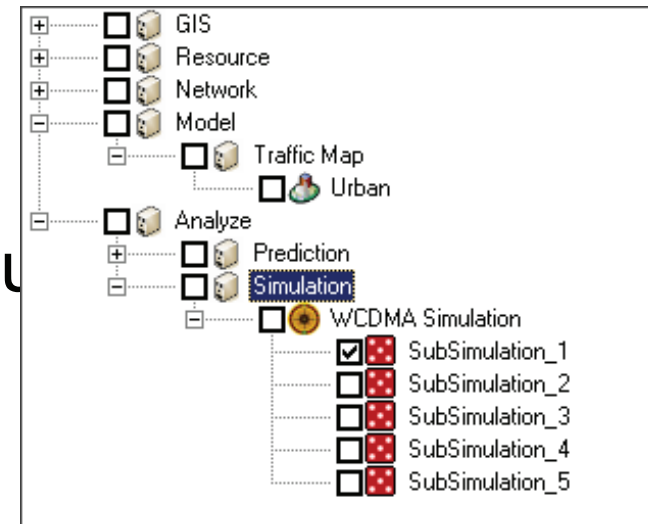


Results (Prediction)

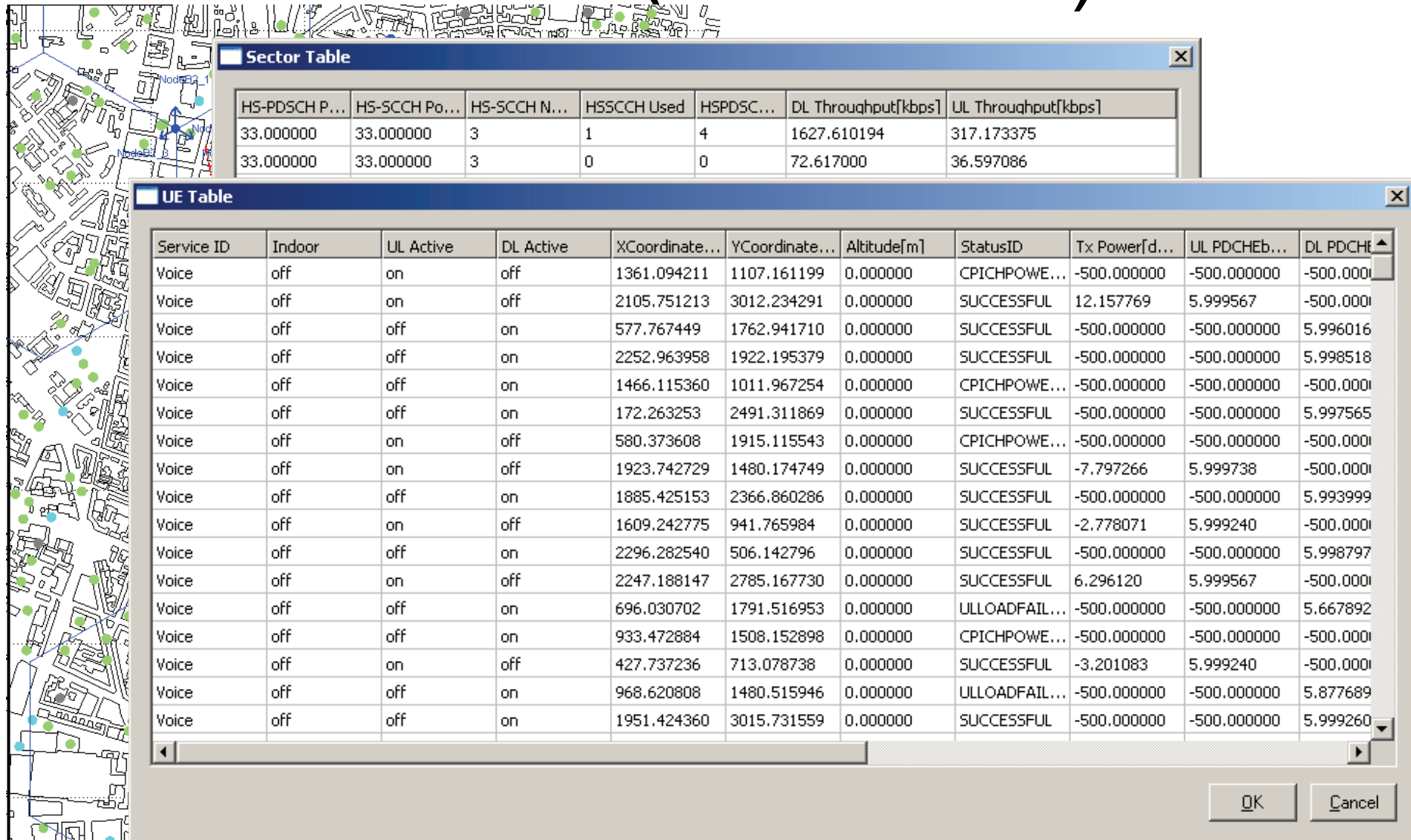


Analyses (Simulation)

- Pluggable API
 - Static System Level Simulation
 - WCDMA/HSDPA
 - WiMAX
 - LTE
 - Dynamic System Level Simulation
 - WiMAX



Results (Simulation)

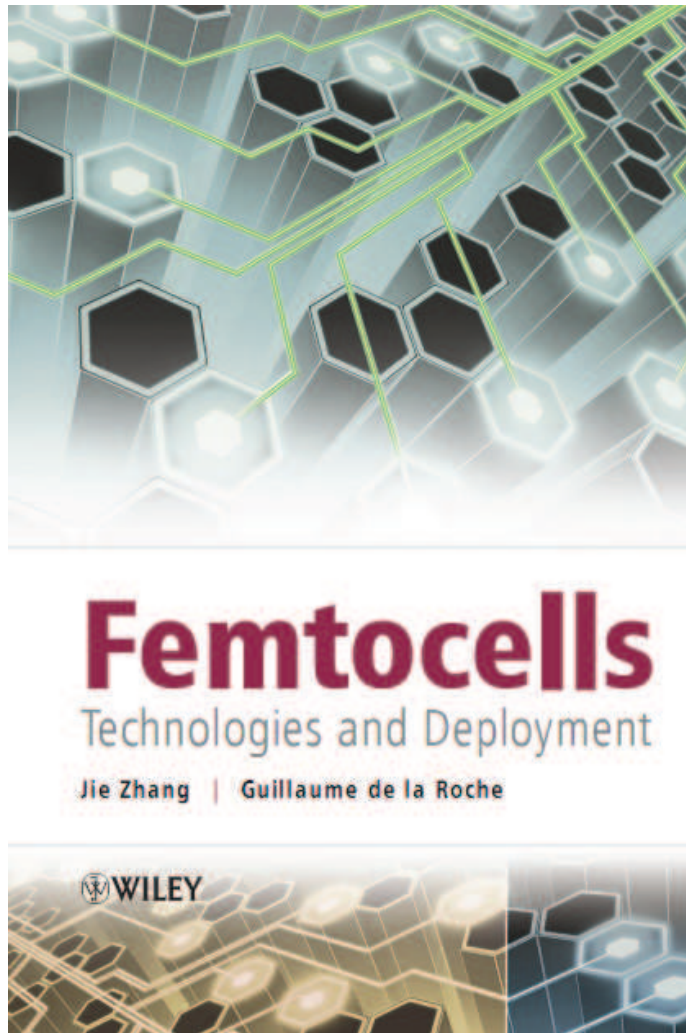


Automatic RAN planning and optimisation

- Refer to our papers in IEEE JSAC, IET Communications, etc for details.

Femtocells

- CWiND was awarded the 1st EPSRC-funded research project on femtocells.
 - Principal Investigator: Dr Enjie Liu
 - Co-Investigator: Prof. Jie Zhang
- In terms of outputs, CWiND is the leading academic research group in femtocell research
 - One book
 - More than 10 papers



- “**Femtocells – Technologies and Deployment**”, Wiley, Dec 2009 or Jan. 2010. 336 pages
 - Order from www.wiley.com or Amazon.
- D. López-Pérez, A. Valcarce, G. De La Roche and J. Zhang, “**OFDMA femtocells: A roadmap on interference avoidance**,” IEEE Communications Magazine, September, 2009.
- G. De La Roche, A. Valcarce, D. López-Pérez and J. Zhang, “**Access Control Mechanisms for Femtocells**,” IEEE Communications Magazine, Sept. 2009.
- H. Song, E. Liu, and J. Zhang, “**An Evolution Roadmap of Mobility Management in hybrid femto/macrocell networks**,” IEEE Communications Magazine, (submitted).
- D. López-Pérez, A. Ladanyi, A. Juttner, and J. Zhang, “**Sensing and Tuning Techniques for the Self-organization of the Sub-channel Allocation in OFDMA Femtocell Networks**,” IEEE Trans. on Wireless Communications, (submitted).

- A. Valcarce, G. De La Roche, A. Jüttner, D. López-Pérez and J. Zhang, "**Applying FDTD to the coverage prediction of WiMAX femtocells,**" in EURASIP Journal of Wireless Communications and Networking. Volume 2009, Article ID 308606, 13 pages.
- D. López-Pérez, A. Ladanyi, A. Jüttner and J. Zhang, "**OFDMA femtocells: A self-organizing approach for frequency assignment,**" in IEEE PIMRC (Personal, Indoor and Mobile Radio Communications), Tokyo, Japan, September 2009.
- A. Valcarce, D. López Pérez, G. De La Roche and J. Zhang, "**Limited Access to OFDMA femtocells,**" in IEEE PIMRC, Tokyo, Japan, September 2009.
- A. Valcarce, D. López-Pérez, G. De La Roche and J. Zhang, "**Predicting small-scale fading distributions with Finite-Difference methods in Indoor-to-Outdoor scenarios,**" in IEEE VTC 2009-Spring, Barcelona, April 2009.
- D. López-Pérez, A. Valcarce, G. De La Roche and J. Zhang, "**Access Methods to WiMAX Femtocells: A downlink system-level case study,**" in IEEE International Conference on Communication Systems (ICCS), Guangzhou, China, November 2008.
- D. López-Pérez, G. De La Roche, A. Valcarce, A. Jüttner and J. Zhang, "**Interference Avoidance and Dynamic Frequency Planning for WiMAX Femtocells Networks,**" in IEEE International Conference on Communication Systems (ICCS), Guangzhou, China, November 2008.

Collaboration areas/topics

Collaboration Area 1 – Simulation Platform (FDD and TDD-LTE)

- **Goal:** To jointly develop a simulation platform that include modules on both FDD and TDD-LTE with Chinese partners
 - Link level
 - System level (both static and dynamic)
- **Purposes:**
 - To do comparative studies of FDD- and TDD-LTE
 - Research on RRM, SON, ...
 - Define standard features and procedures in simulation platform design and development.

Collaboration Topic 1 – Simulation Platform (FDD and TDD-LTE)

- Other modules can also be included, e.g., TD-SCDMA and CDMA2000
 - To study heterogeneous networks.
- Extend the platform for Cognitive Radio research.

Collaboration Area 2 – Femtocells

- LTE femtocells:
 - Self organisation: self-configuration, self-optimisation, self-healing.
 - Preferably with industrial partners. E.g, Huawei's UMTS femtocells do not have self Tx power adaptation.
 - Interference modelling, analysis and mitigation (academic partners are preferred)
 - Uplink
 - Downlink
 - Access control mechanisms for femtocells
- Beamforming and MIMO for femtocells.
- ...

Other Collaboration Topics

- SON for LTE
- Indoor – outdoor radio propagation
- Localisation (positioning) in indoor environments
- Indoor channel modelling and measurement
 - MIMO channel modelling in indoor environments
 - Channel characterisation in the transition from LOS to NLOS due to moving objectives.

Thanks! Questions?

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