Tutorial on
Small Cell/HetNet Deployment

Part 1: Evolutions towards small cell and HetNet

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Outline

1. An overview of the tutorial
2. Evolutions towards small cell/HetNet
3. Challenges of small cell/HetNet deployment
4. Some of our publications on small cell/HetNet deployment

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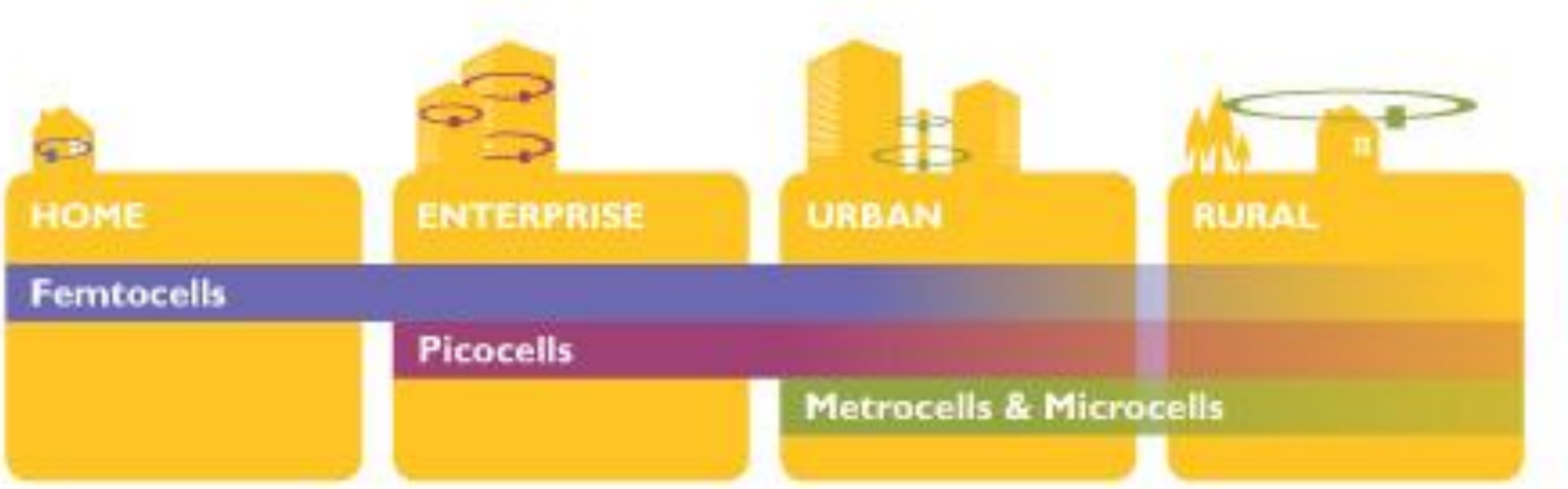
1. An overview of the tutorial

- **Part 1:** Evolutions towards small cell and HetNet
- **Part 2:** Interference in small cell and HetNet
- **Part 3:** SON for small cell and HetNet
- **Part 4:** Small cell backhaul
- **Part 5:** Tools for small cell and HetNet deployment

2. Evolutions towards small cell/HetNet

What is a small cell?

- Small cells are **low-power** wireless **access points** that operate in **licensed spectrum**.
- Small cells provide improved cellular coverage, capacity and applications for **homes** and **enterprises** as well as **metropolitan** and **rural public spaces**.



Source: www.smallcellforum.org

What is a small cell?

- Types of small cells include **femtocells**, **picocells**, **metrocells** and **microcells**
  - broadly increasing in size from femtocells (the smallest) to microcells (the largest).

- Small-cell networks can also be realized by means of distributed radio technology consisting of **centralised baseband units** and **remote radio heads**.

Source: www.smallcellforum.org

What is HetNet?

- HetNet could mean a network comprising of different RATs (WiFi, GSM, UMTS/HSPA, LTE/LTE-A)
  - Multi-RATs from multi-vendors will co-exist in the next decades
- A HetNet also means a network consisting different access nodes such as macrocell, microcell, picocells, femtocells, RRHs (Remote Radio Heads), as well as relay stations.
  - Leads to two (multiple) tier/layer networks
- In this tutorial, we will focus on HetNet that comprises of different access nodes.

Small cell & Macrocell coverage & transmission power

- Small cell
  - **Coverage:** Typically 10m to 200m cell radius within urban and in-building locations, up to 2km cell radius in rural areas.
  - **Transmission power:** 20 mW to 2W

- Macrocell:
  - **Coverage:** Typically cell radius is a few kilometres, up to 35 km
  - **Transmission power:** 20-40W

Capacity, configuration of small cells

	Femtocell	Enterprise Femtocell	Picocell	Metrocell
Capacity	4-8 channels	16-32 channels	32-64 channels	32-64 channels
Configuration	Automatic	Automatic	Automatic or manual	Automatic or manual
Power Output	20mW	200mW	200mW - 2W	200mW - 2W
Handoff	Hard	Soft, hard	Soft, hard	Soft, hard
Location	Indoor	Indoor	Indoor/Outdoor	Outdoor

Note: Use UMTS/HSPA small cell as an example.
Soft handover applies to CDMA based small cells.

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Evolutions towards small cell & HetNet

- Macrocell Driven Small Cell Solutions
  - Microcell
  - Microcell + RRH
  - Distributed Base Station
- Femtocell Driven Small Cell Solutions
  - Femtocell
  - Picocell
  - Metrocell

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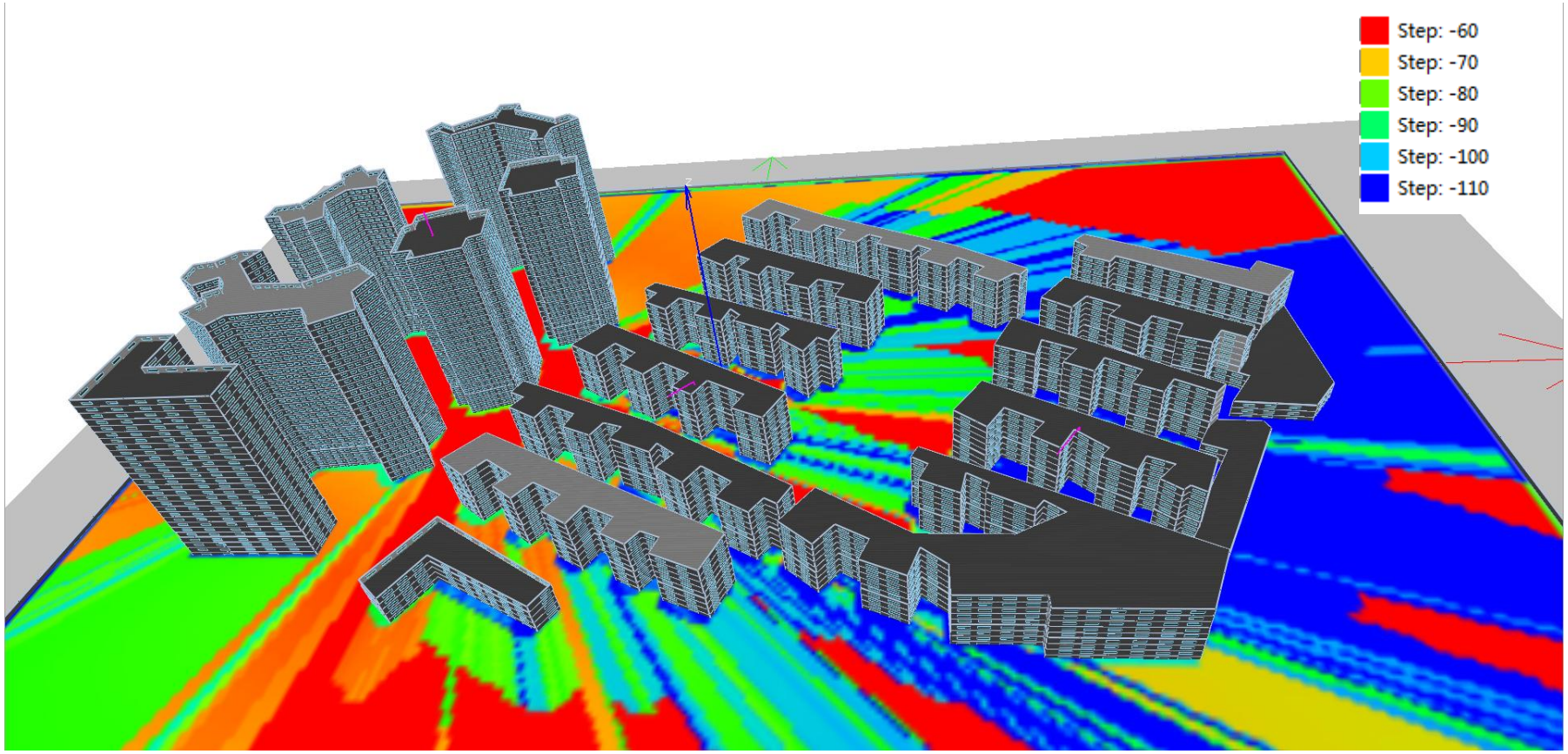
Overview of a Dense Urban Scenario

Macrocell only is not good enough (red: signal level, >-60 dBm; dark blue: signal level <-110 dBm)



Scenarios generated using ***Ranplan-SmallCell™ tools***

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Macrocell Driven Small Cell Solutions

- Driven from Macrocell
- Motivations
  - Fill coverage holes where macrocell can not reach
  - Provide higher capacity density for dense urban area
  - Smaller footprint, lower energy consumption

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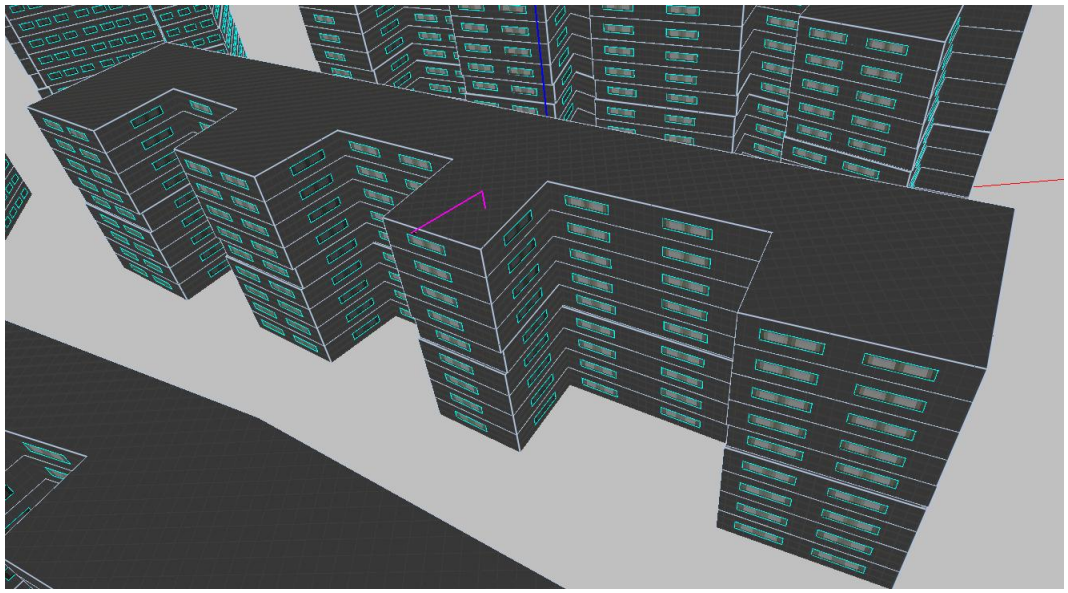
Microcell

Parameters	Value
Output Pwr.	10 ~ 2000mW
Coverage	100 ~ 1000m
Support User	> 100
Scenario	Outdoor



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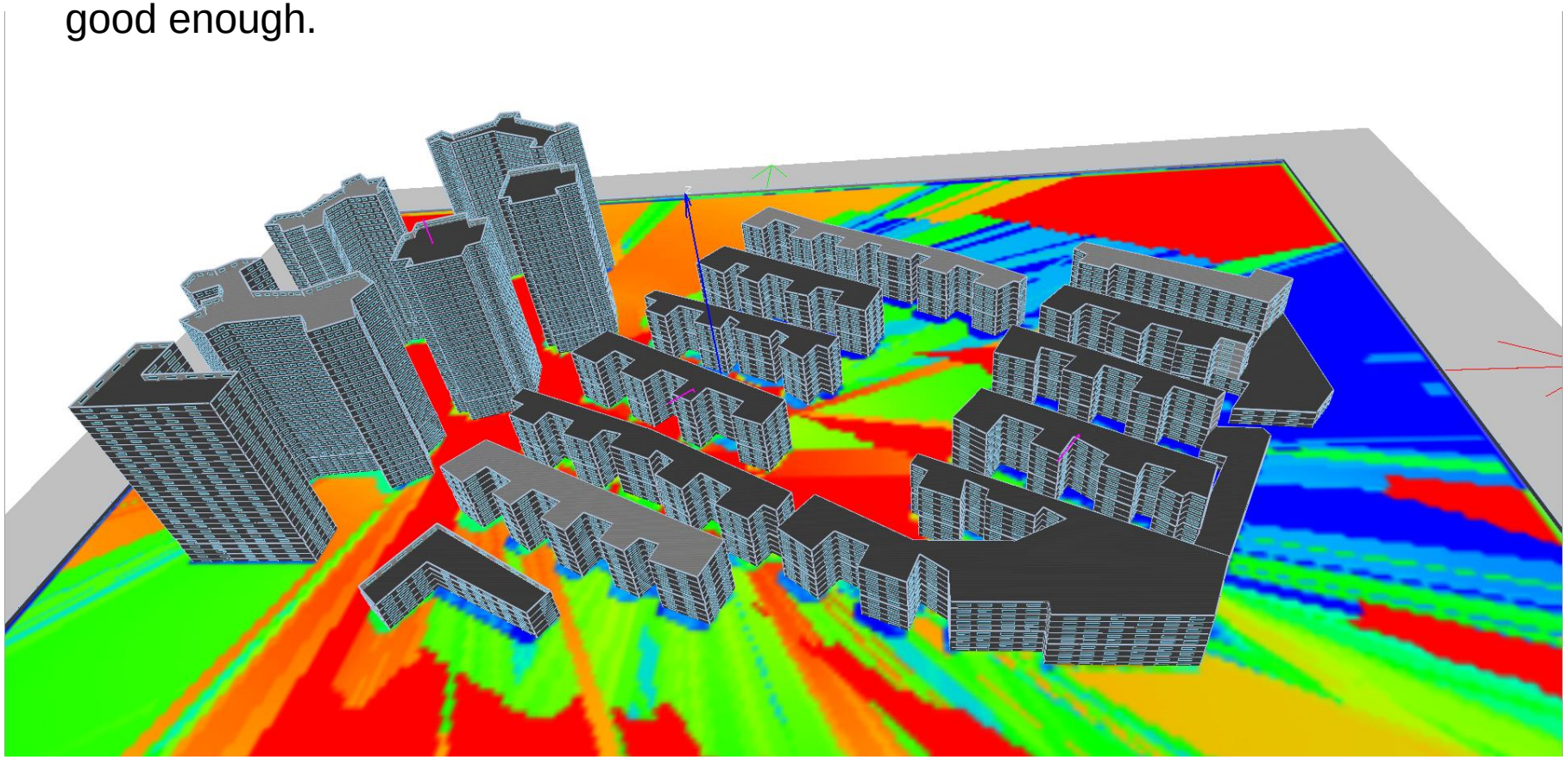
Macrocell + Microcell Solution

Deploy a microcell on a lower building in the middle will improve but still not good enough.

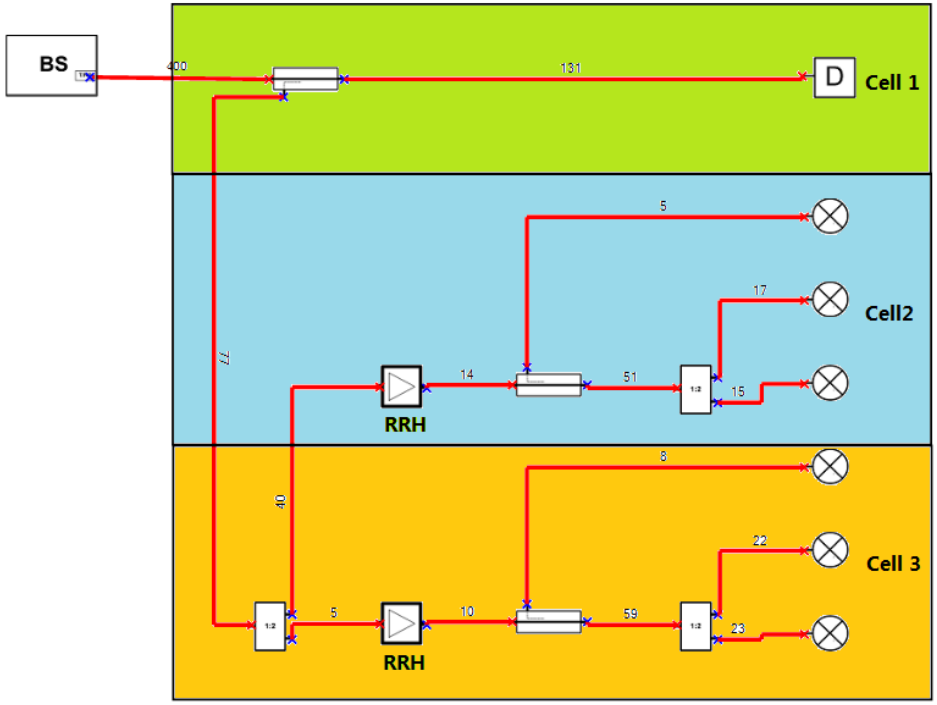


Scenarios generated using ***Ranplan-SmallCell™ tools***

Microcell + RRH

Further split the microcell into smaller cells using RRHs

Parameters	Value
Output Pwr.	10 ~ 100mW
Coverage	50 ~ 100m
Support User	> 100
Scenario	Outdoor Indoor



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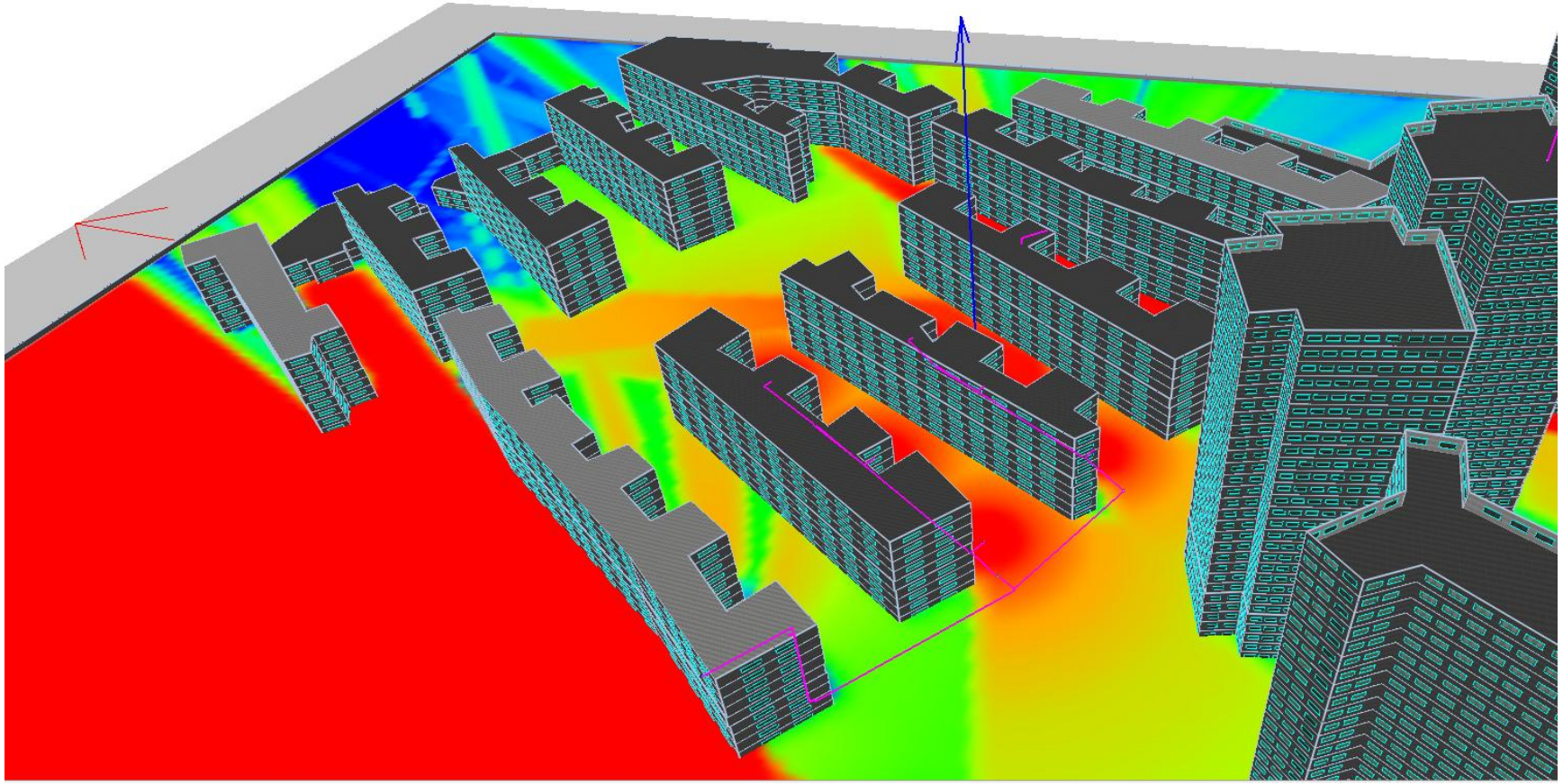
Outdoor signals have been greatly improved. Some indoor coverage is OK, but not all.



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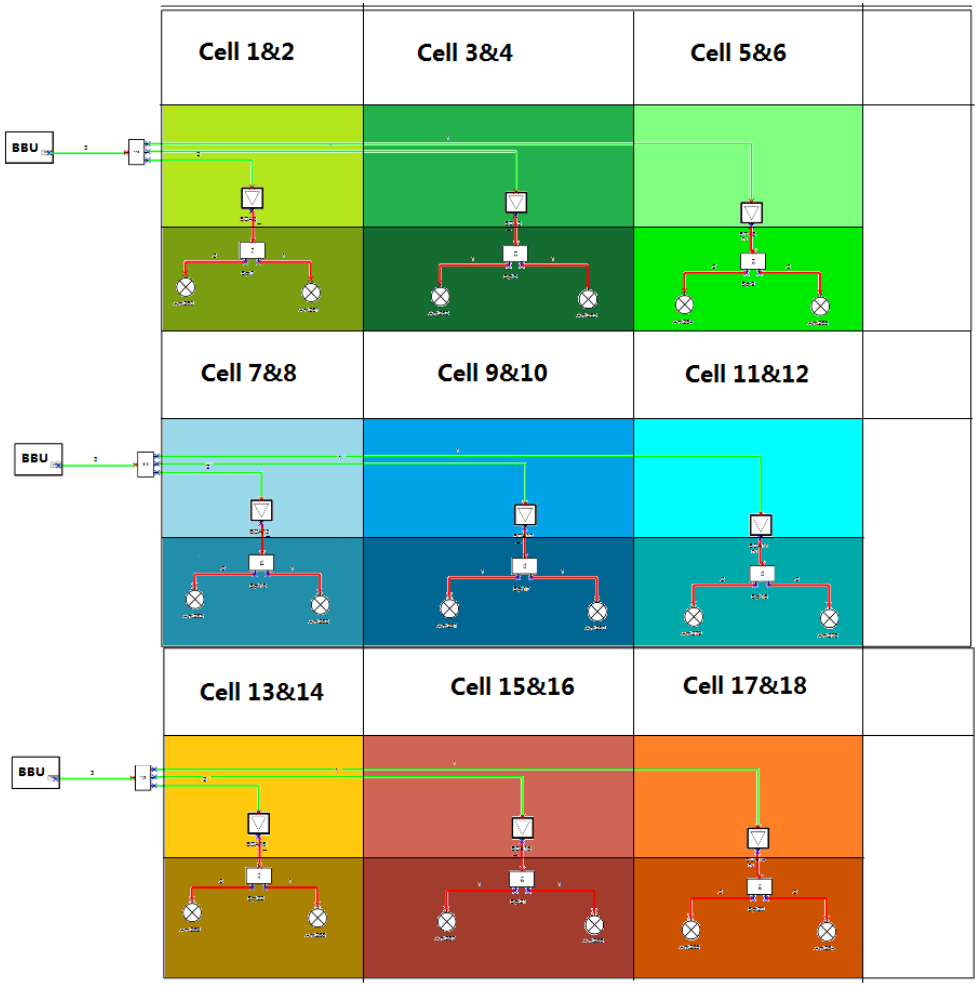
Distributed Base Station

Parameters	Value
Output Pwr.	1 ~ 10mW
Coverage	10 ~ 20m
Support User	> 100
Scenario	Indoor Outdoor



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Distributed Base Station

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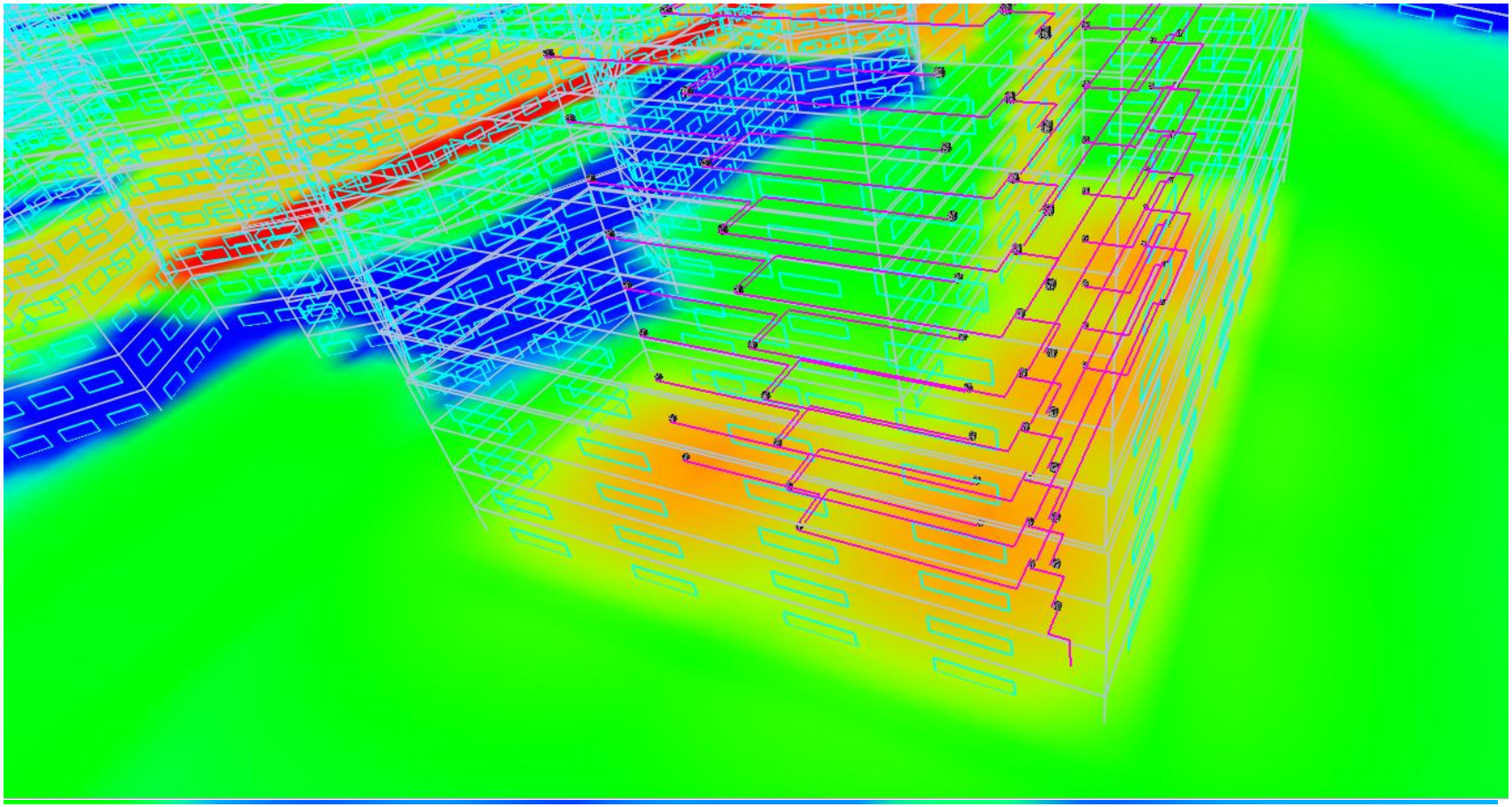
- DBS/DAS can provide high capacity and distribute signal more evenly.



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Femtocell Driven Small Cell Solutions

- Driven from Femtocell
- Motivations
  - Support more users or SME/Metro area
  - Provide larger coverage for wider area
  - Adapt to more scenarios other than residential

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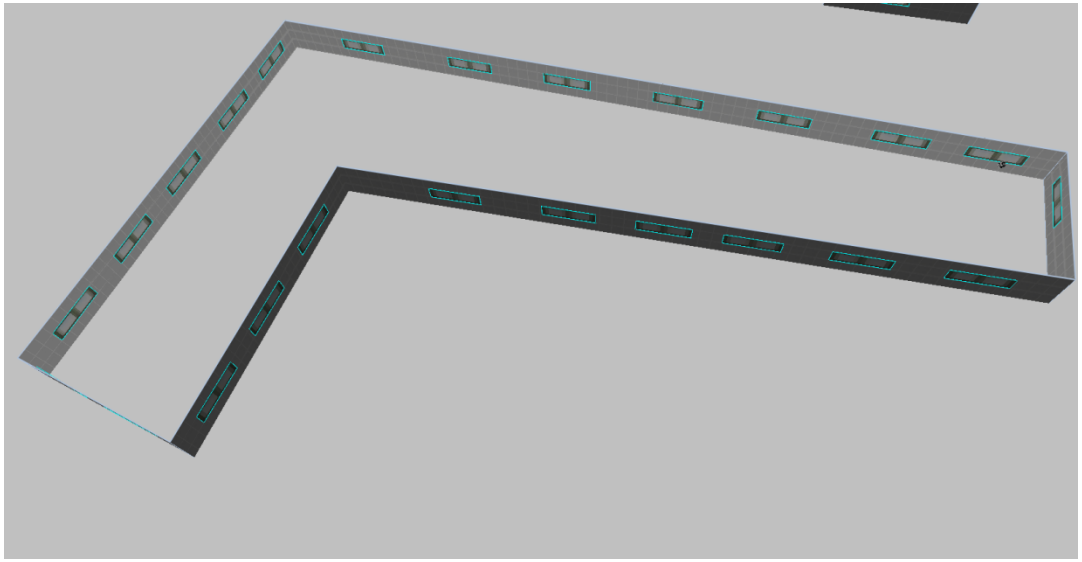
Femtocell

Parameters	Value
Output Pwr.	1 ~ 20mW
Coverage	10 ~ 20m
Support User	4 ~ 8
Scenario	Indoor



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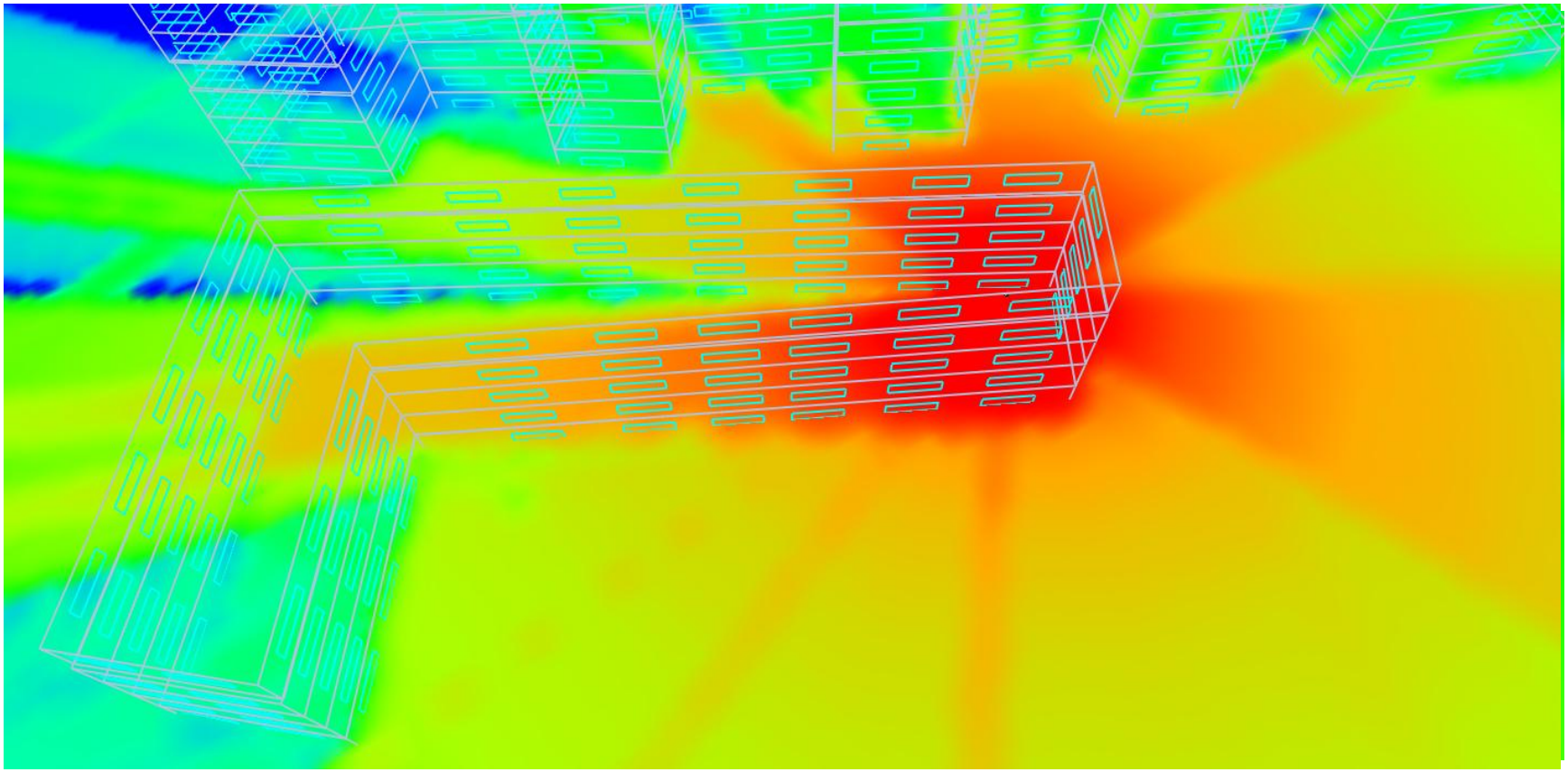
Femtocell



Scenarios generated using ***Ranplan-SmallCell™ tools***

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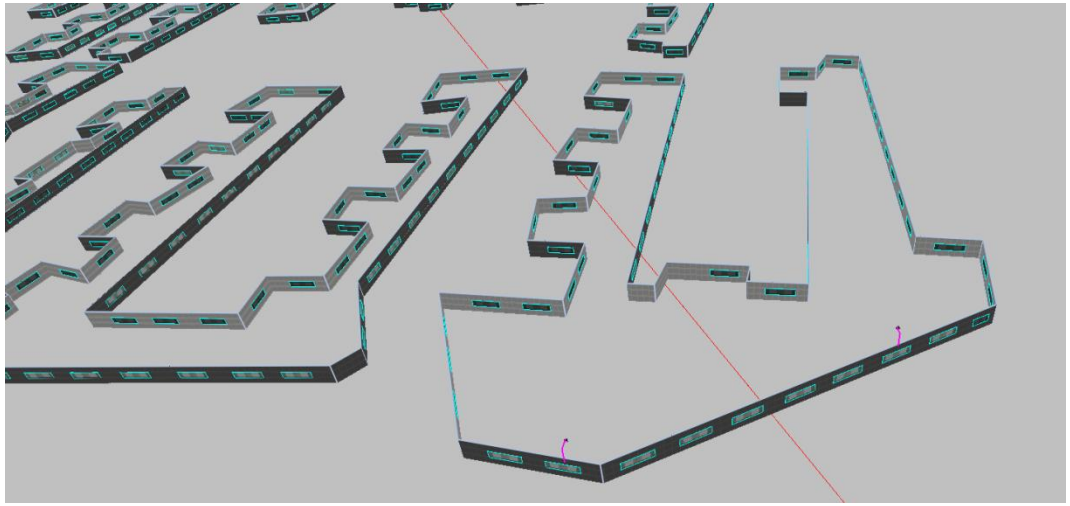
Picocell

Parameters	Value
Output Pwr.	20 ~ 250 mW
Coverage	50 ~ 100m
Support User	16~32
Scenario	Indoor Outdoor



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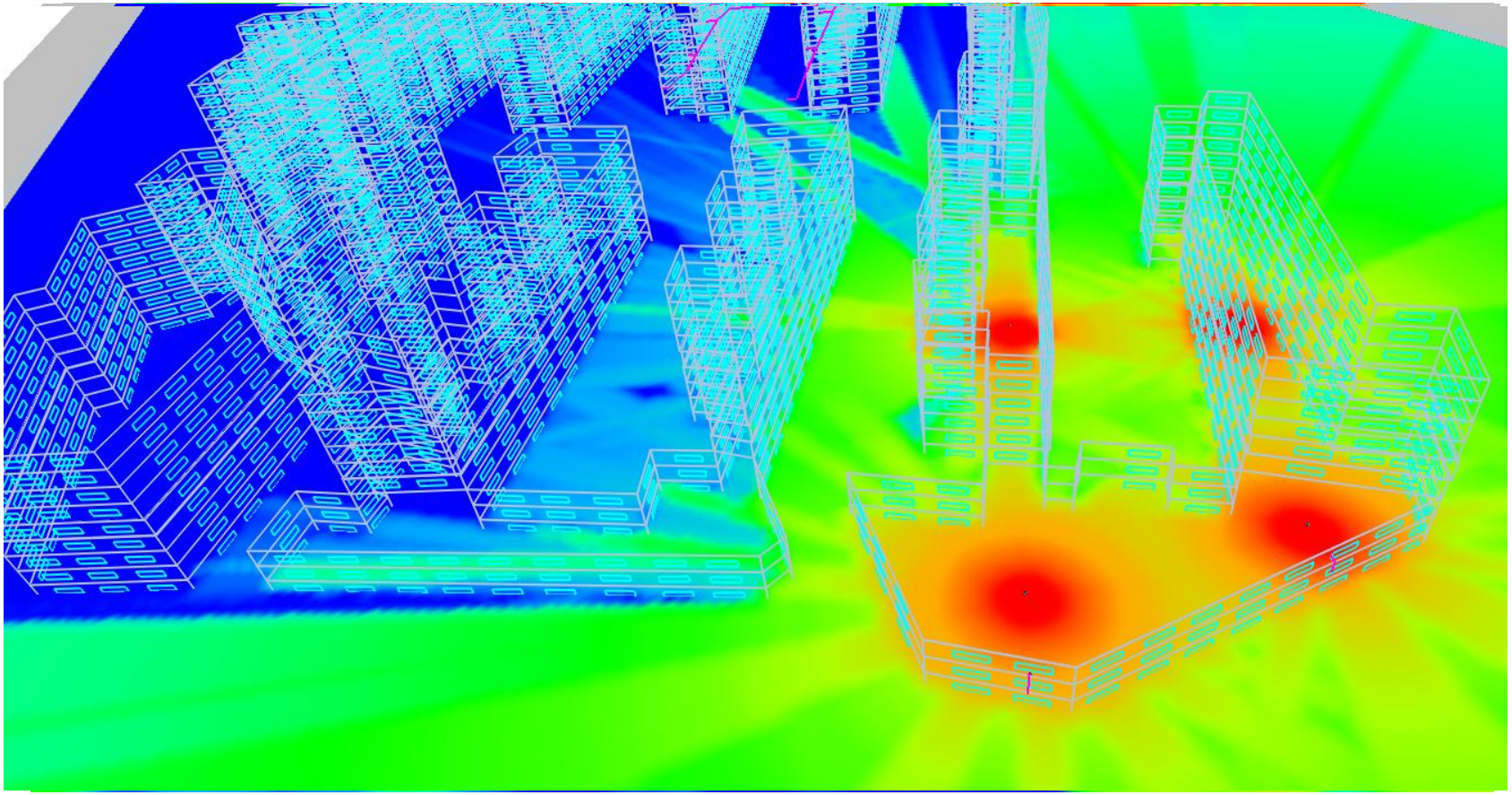
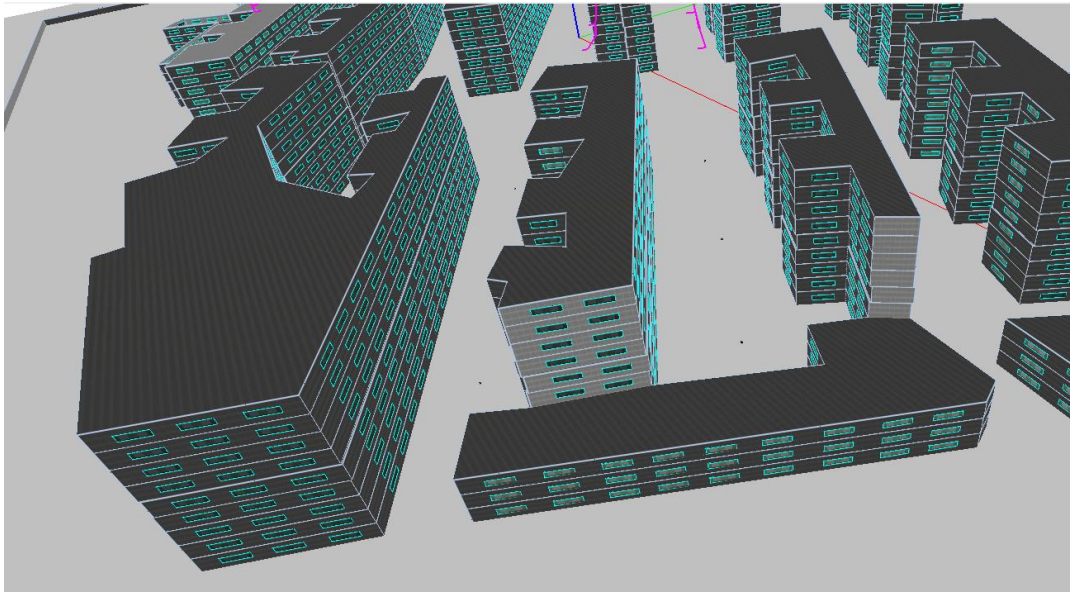
Picocell (indoor)



Metrocell (outdoor)

Parameters	Value
Output Pwr.	~ 250 mW
Coverage	Up to 2km
Support User	~ 32
Scenario	Outdoor



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Metrocell (outdoor)

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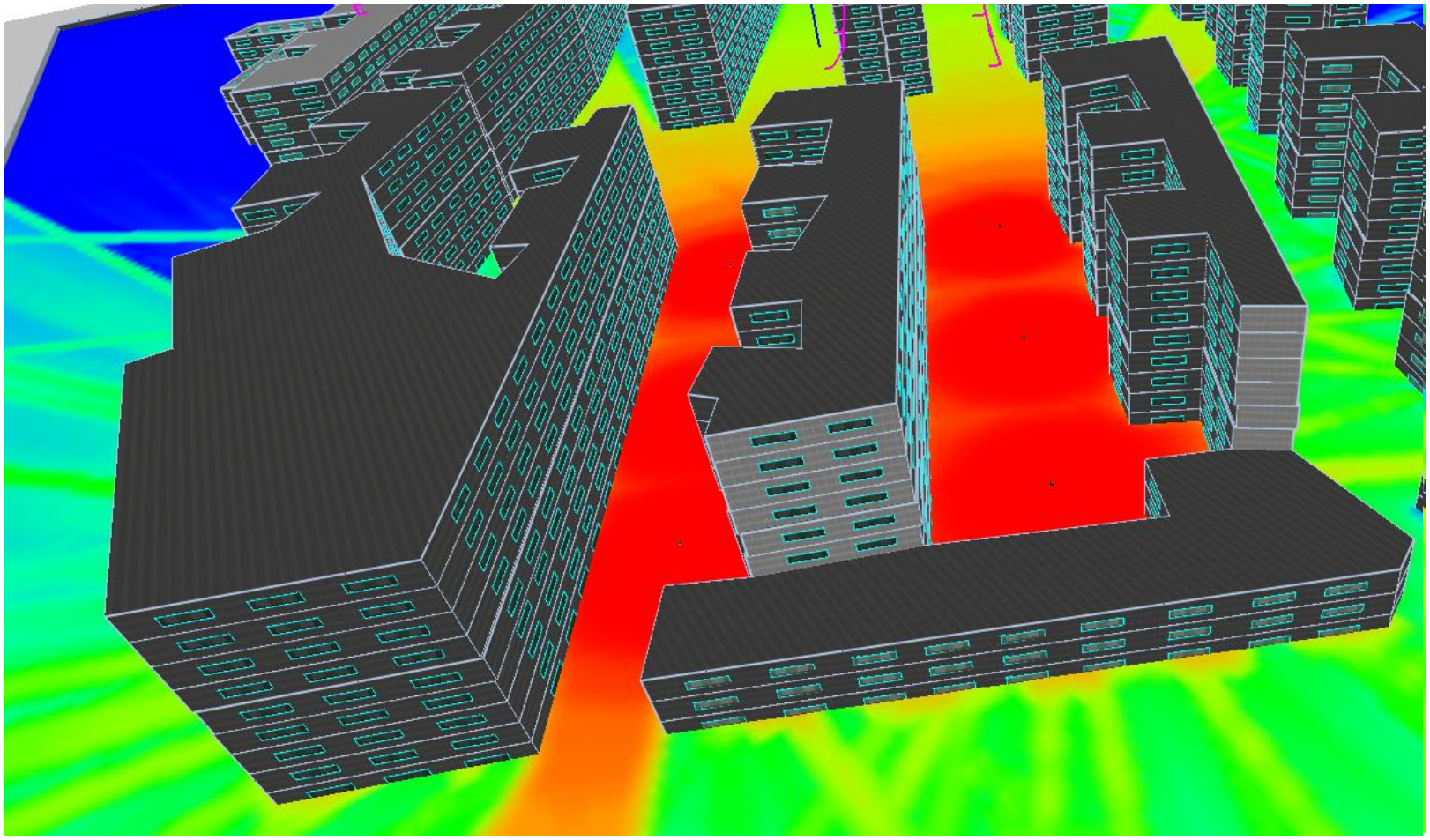
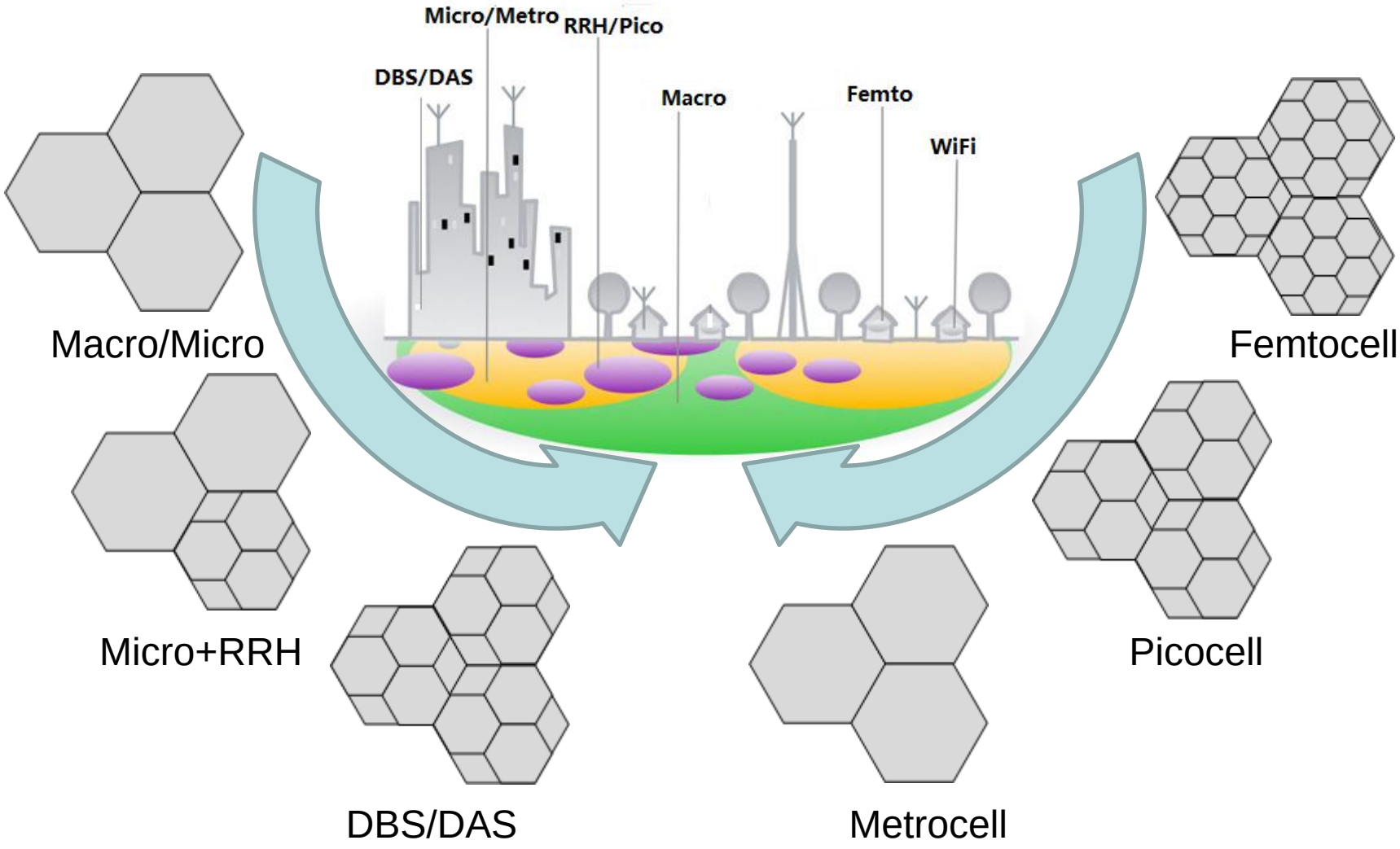


Evolution to HetNets



Small Cell Typical Deployment Scenarios

- Home
- Enterprise
- Hot spots (indoor and outdoor)
- Emergency
- Airplanes
- On the move (bus, taxi)

3. Technical challenges of small cell/HetNet deployment

- Interference
- Self-organization
- Mobility management, e.g., handover
- Access control methods
- **Backhauling (4G: 1Gbps; B4G: >10Gbps)**

- The first four challenges were identified in an EPSRC-funded femtocell project that we submitted in 2007. They are still valid today.

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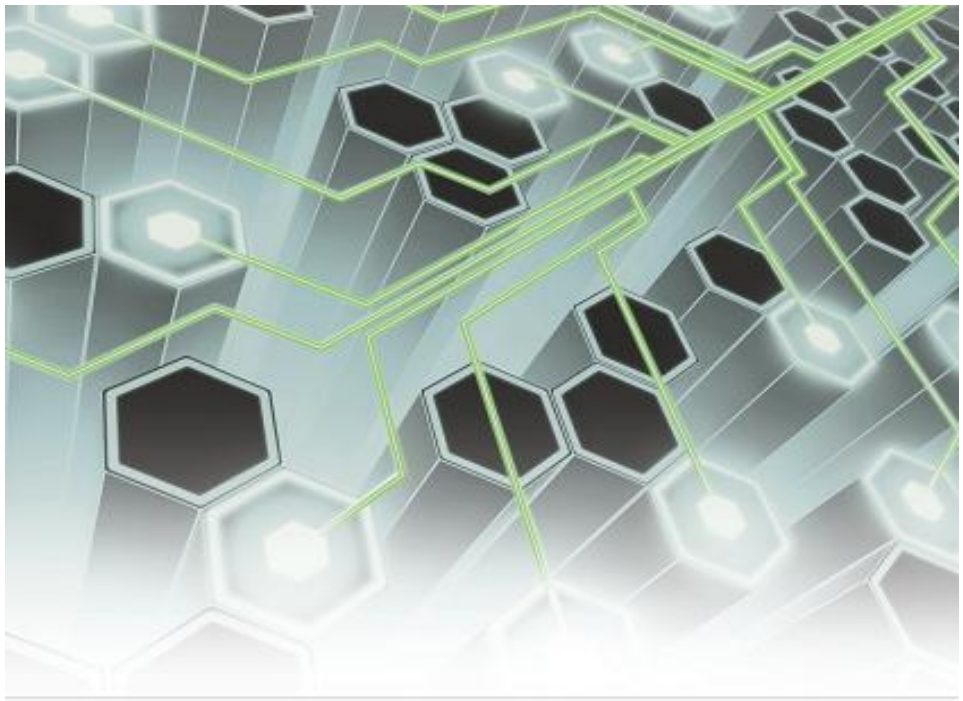
4. Some of our publications on Small Cell/HetNet deployment

Some of our early work on femtocells

- D. López Pérez, A. Valcarce, G. De La Roche, **J. Zhang**, "**Access Methods** to WiMAX Femtocells: A downlink system-level case study," in IEEE ICCS, November 2008.
- D. López-Pérez, G. De La Roche, A. Valcarce, A. Jüttner, **J. Zhang**, "Interference Avoidance and Dynamic Frequency Planning for WiMAX Femtocells Networks," IEEE ICCS, November 2008.
- D. Lopez, A. Valcarce, G. De La Roche and **J. Zhang**, "**OFDMA femtocells: A roadmap on interference avoidance**," *IEEE Communications Magazine*, vol. 47 (9), Sept. 2009. Currently **the most widely cited among over 1000 femto papers).** [>260 citations]
- G. De La Roche, A. Valcarce, D. López-Pérez and **J. Zhang**, "Access Control Mechanisms for Femtocells," *IEEE Communications Magazine*, vol. 48(1), Jan. 2010.

- All the above papers attracted a large number of citations
- …… our other work (joint channel, power and MCS allocation, distributed approach, decoupling of DL and UL in HetNet, eICIC in HetNet)



Femtocells

Technologies and Deployment

Jie Zhang | Guillaume de la Roche

New Book (Wiley, Q2 2013)

Small Cells: Technologies and Deployment

Jie Zhang[1,3], David Lopez-Perez[2], Hui Song[3],
Guillaume de la Roche[4], Enjie Liu[5] , Xiaoli Chu[1]

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Thank you for your attention!

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