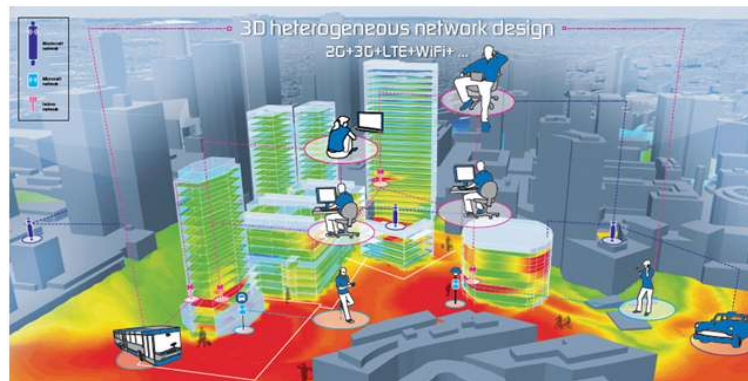


From heterogeneous wireless networks to sustainable efficient ICT infrastructures:



How antenna and propagation simulation tools can help?

Yves Lostanlen

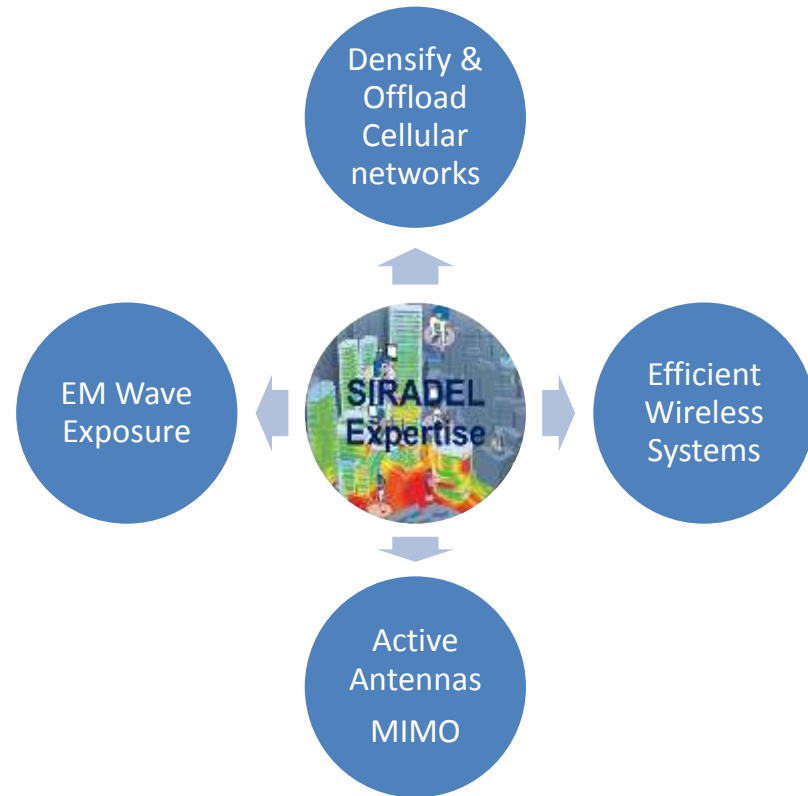
SIRADEL

April 9th 2013, Gothenburg, Sweden

SIRADEL's Research activities

- 1994
- 60+ people
- France, Toronto, Hong-Kong
- 8 FP6-FP7 EU projects
- 35+ collaborative projects
- 100+ research partners

- **4 main investigation areas**



Aim: Developing expertise, methodologies and tools

Data: GIS, RF, traffic

Software: Volcano, VolcanoLab and Smart City Explorer

Consulting: Management & Technology (guidelines)

Outline

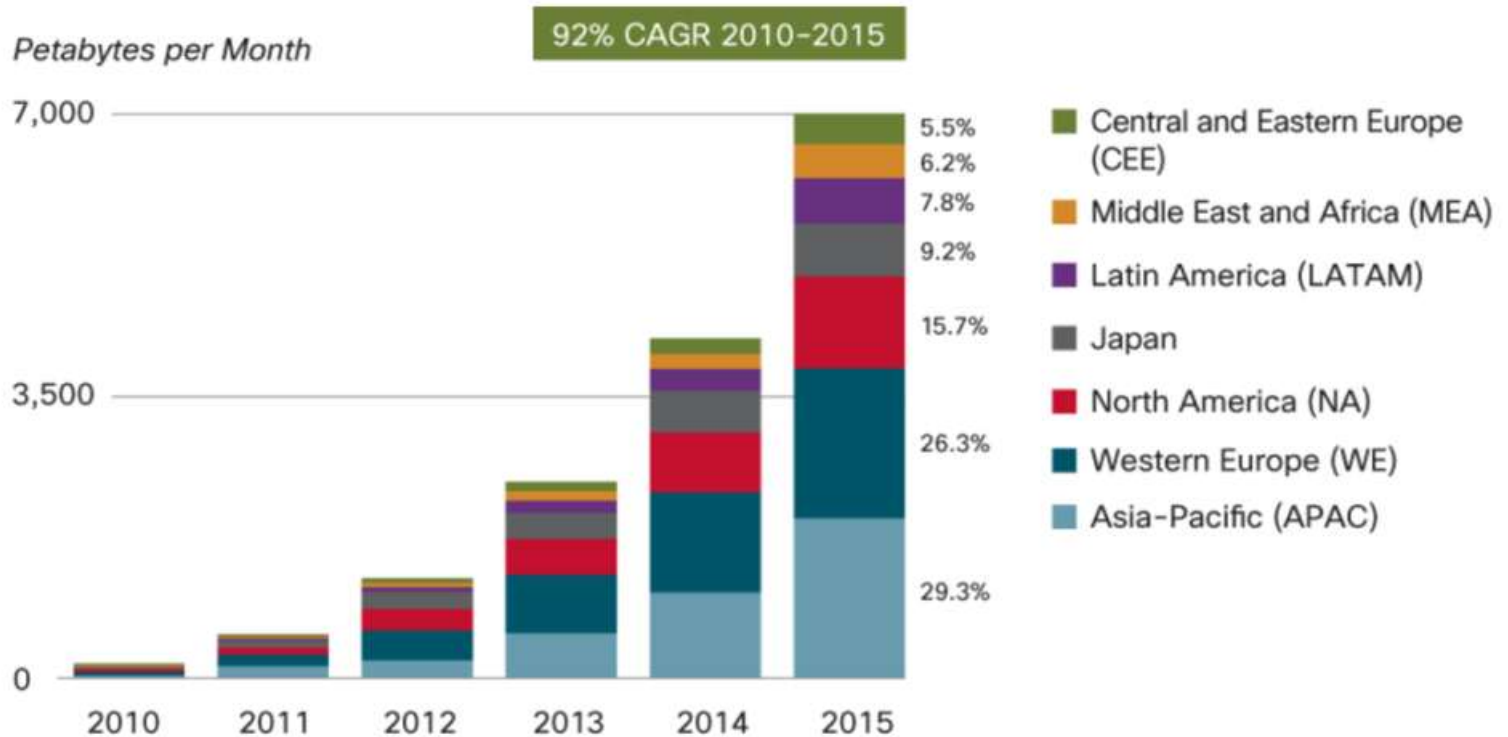
Context

Motivation for Hetnet

Sustainable?

Opportunities!

Data traffic: exponential growth



Source: Cisco VNI Mobile, 2011

Wireless device: Exponential growth

People to People



People to machines



Machines to Machines

Internet

Yesterday
Millions

Internet of
Things
IoT

Today
Billions

Internet of Everything

IoE

Chris Evans
CFO

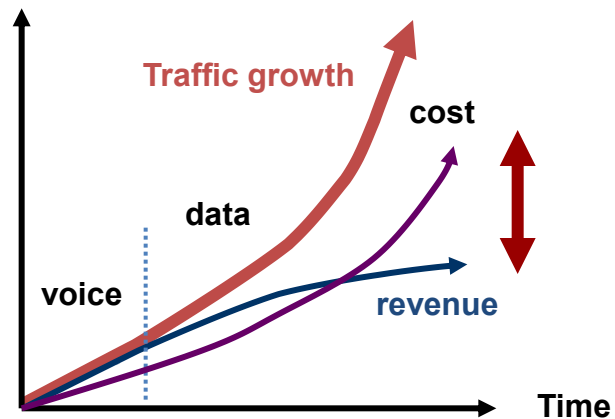
Tomorrow
Trillions

So wireless handsets are everywhere.
Data demand is growing.

Other constraints?

Well... Yes.

- 1. Revenue growth constrained
- Reduce TCO



- 2. Reduce



and



- 3. EMF exposure concerns

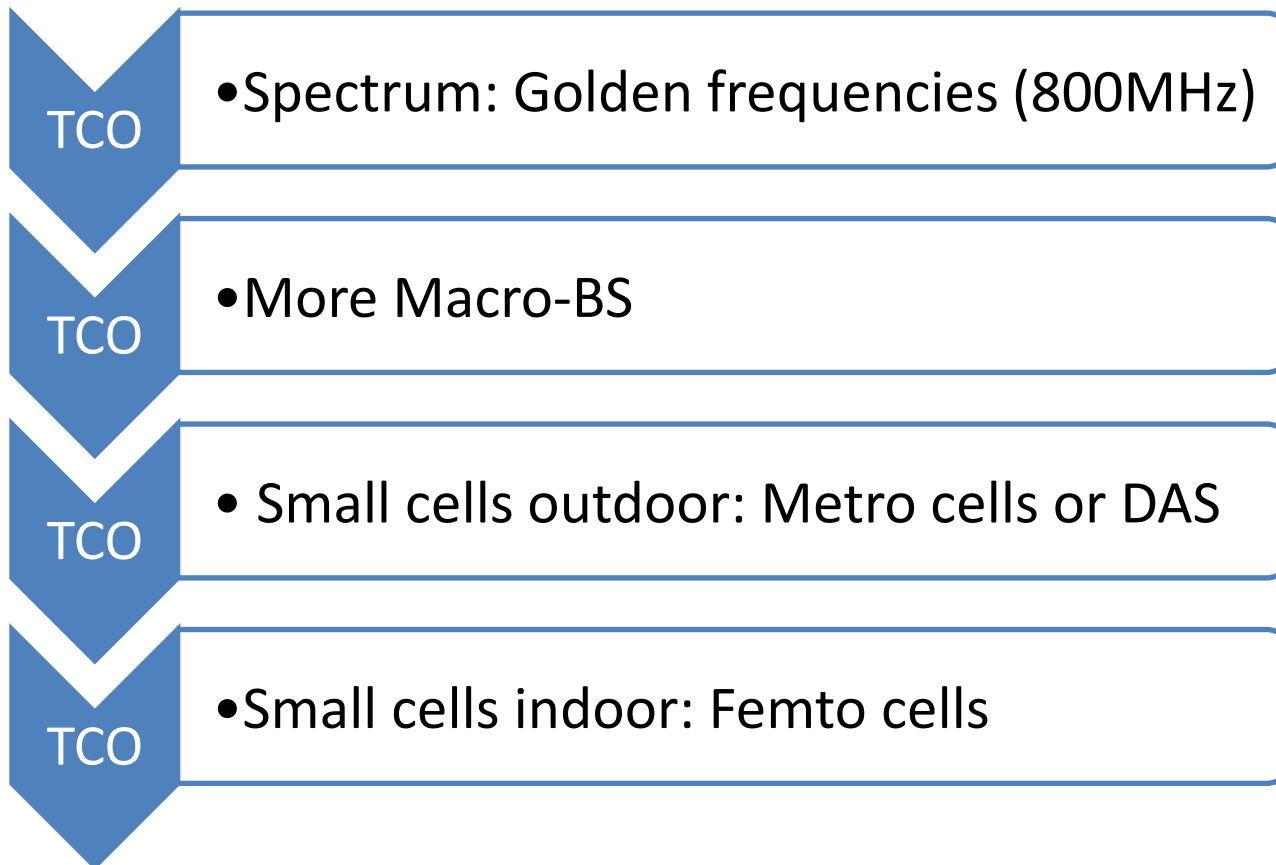


How shall we cope with this traffic demand, and those constraints?

What concepts and tools do we need?

Data growth absorption

$$\text{Capacity} \approx n \cdot W \cdot \log_2(1+\text{SINR})$$



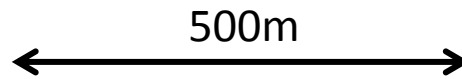
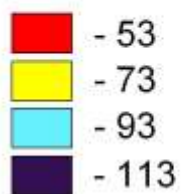
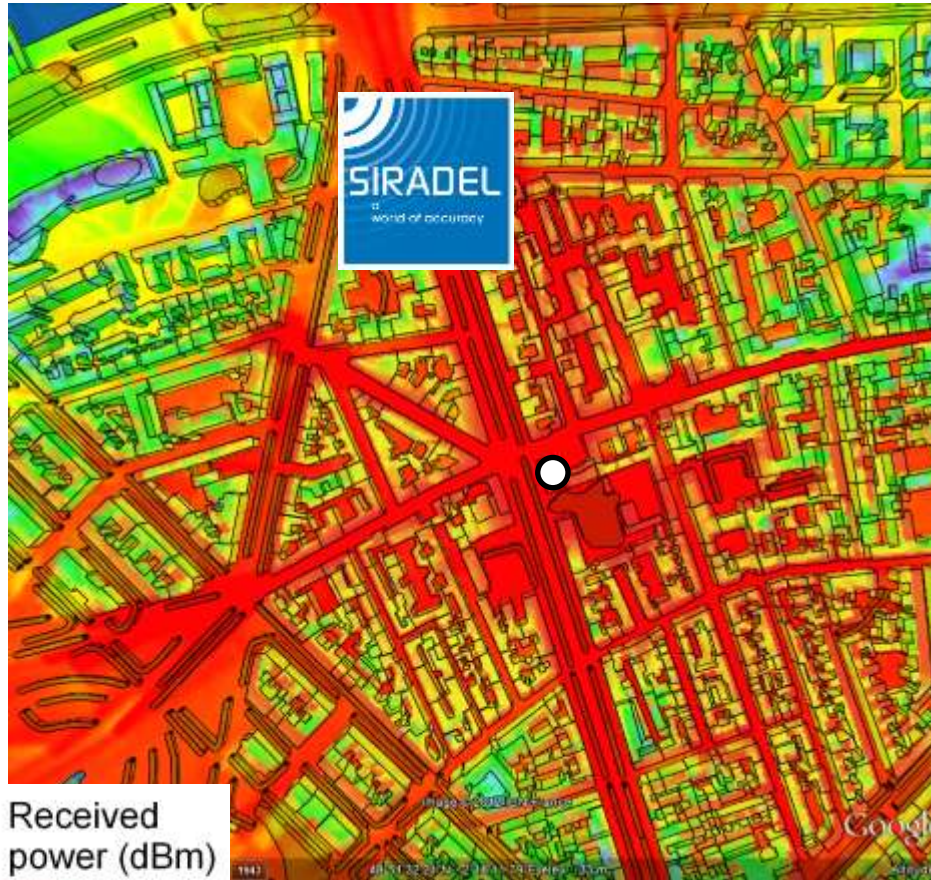
Radio Propagation
& Antenna tools

Spectrum is expensive.

Why do wireless carriers compete so fiercely on golden frequencies?

Golden frequencies vs. 2.6GHz

Macro base station (34m above ground)



Outline

Context

Motivation for Hetnet

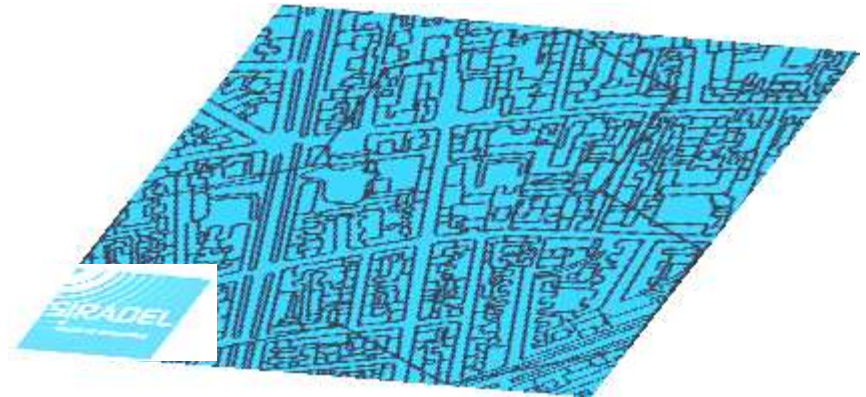
Sustainable?

Opportunities

Macros are great for outdoor coverage or for large regions with uniform low demand

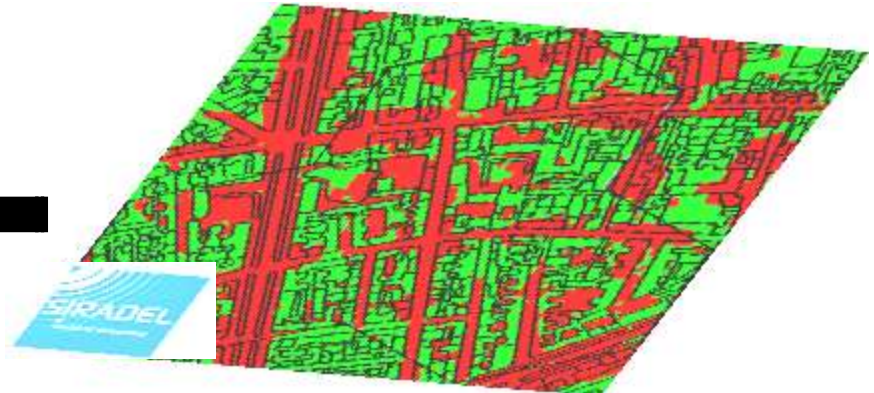
Traffic demand

- High
- Medium
- Low






But demand is not uniform

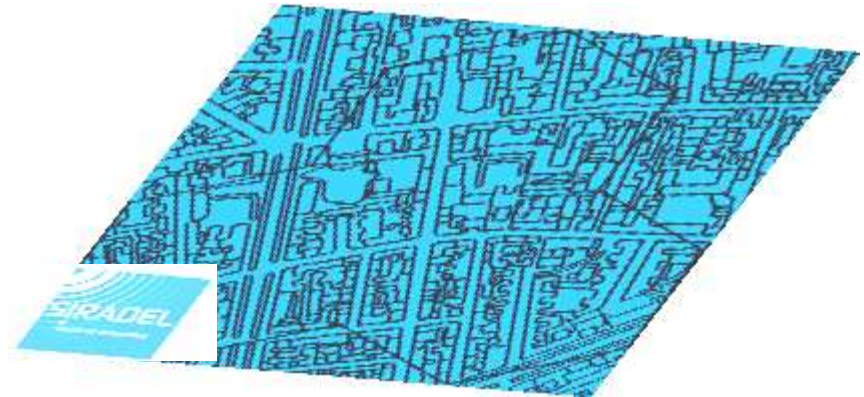
Solutions?



Non uniform
traffic demand

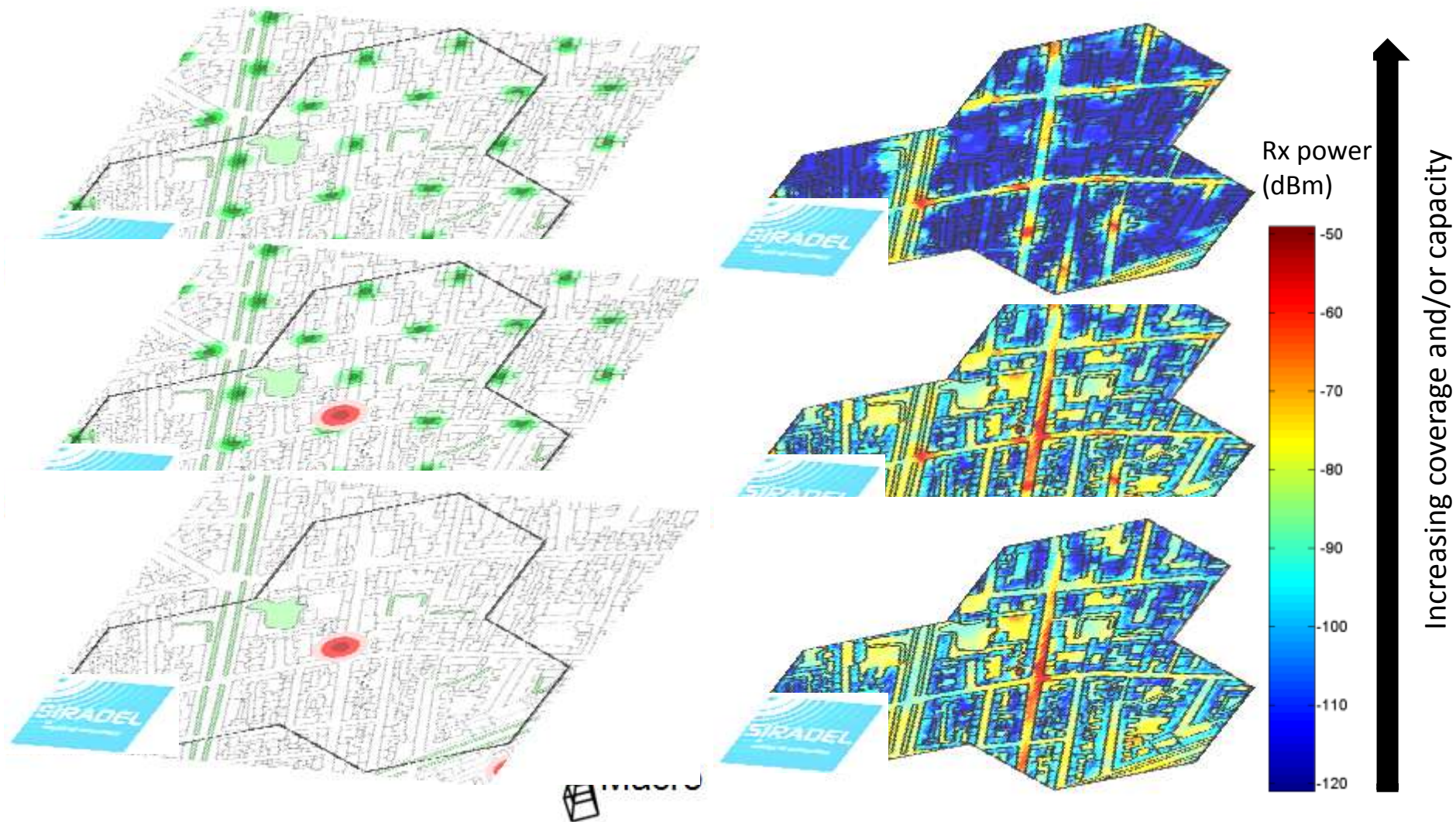
Legend

-  High
-  Medium
-  Low

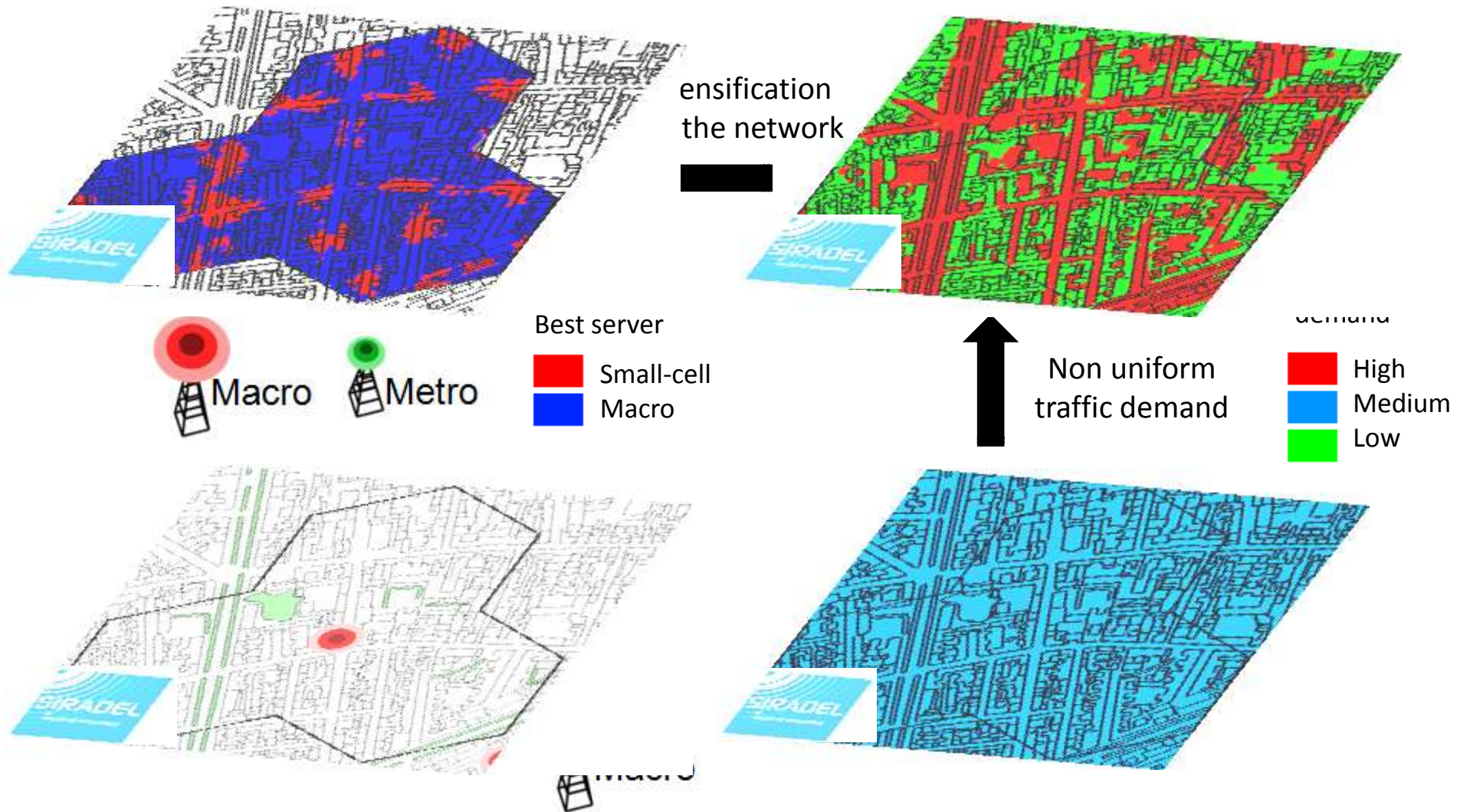


Illumination where it is required

Composition 2-tier coverage



Matching demand and best server



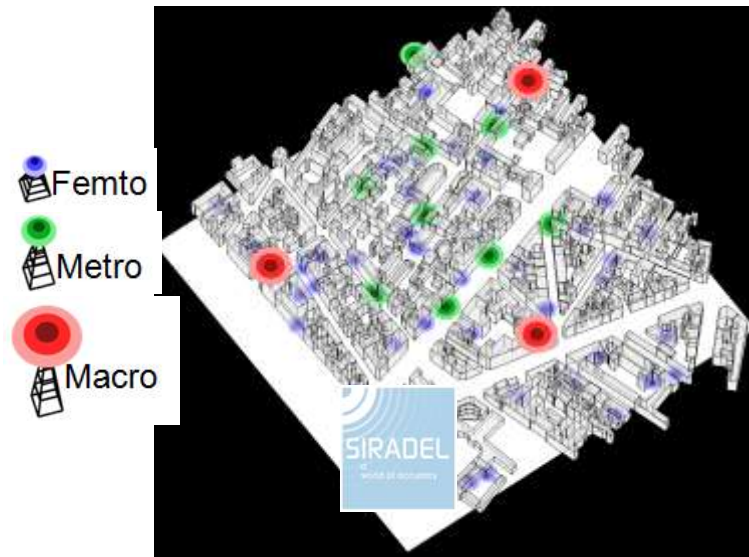
Data growth absorption

More cells

New spectrum

Mitigate interference

$$\text{Capacity} \approx n \cdot W \cdot \log_2(1+\text{SINR})$$



Radio Propagation
& Antenna tools

Small cell challenges

Site Location

- Traditional site acquisition: complex and expensive
- Street furniture: opportunity Optical Fiber / DSL

Interference Management

- Spectrum re-use: same or different spectrum from macro-cells
- Coordination between macro-cells and small cell layer

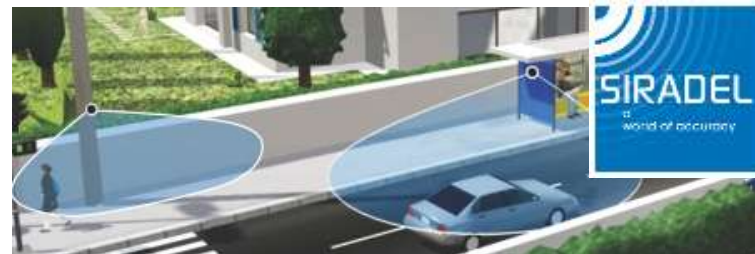
Backhaul

- Various frequency band options
- LOS and NLOS in urban areas
- Enhance flexibility in site location

Small cell challenges

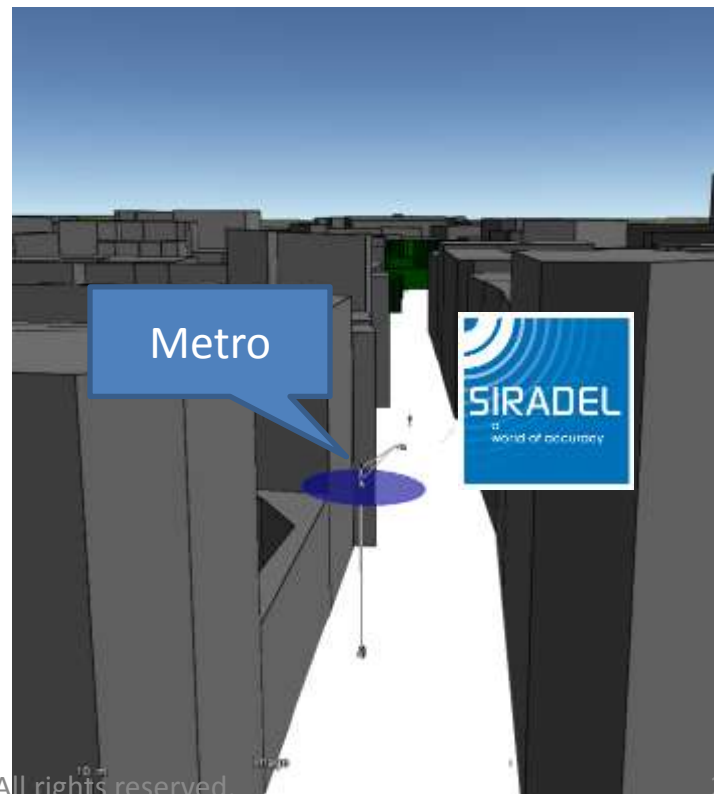
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Interference Management

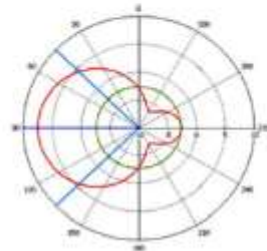
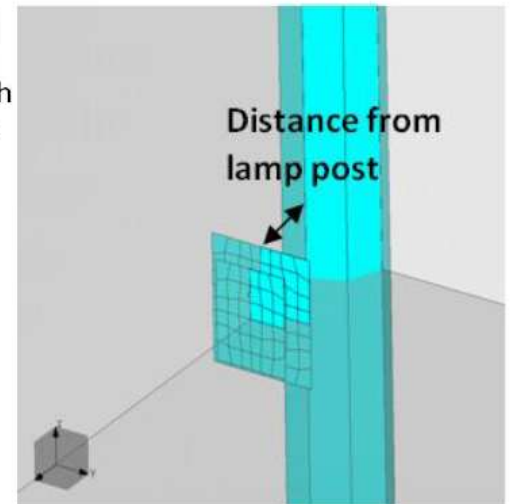
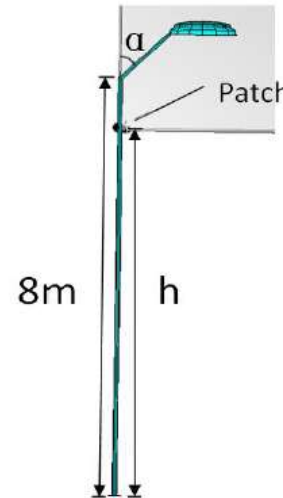
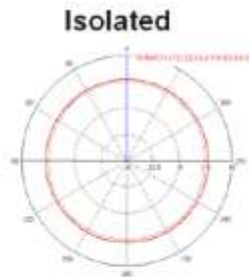
- Spectrum re-use: same or different spectrum from macro-cells
- Coordination between macro-cells and small cells



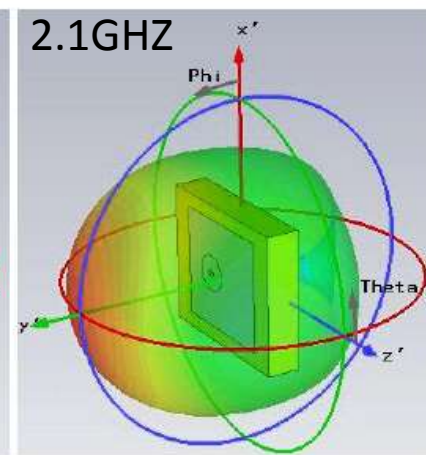
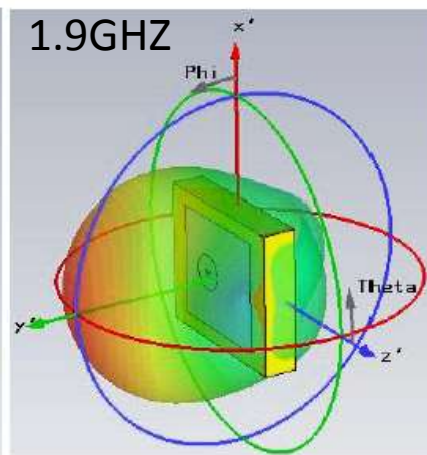
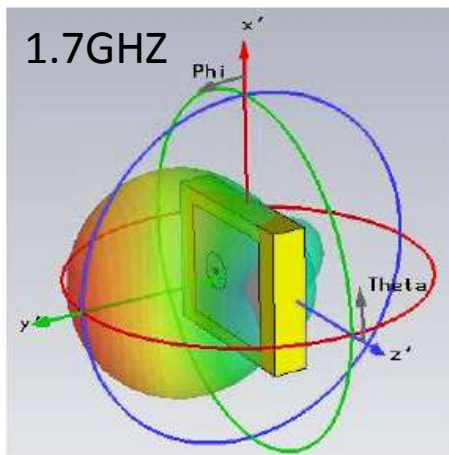
Backhaul

- Various frequency band options
- LOS and NLOS in urban areas
- Enhance flexibility in site location

Once we have the site location, we analyse the antenna patterns in real conditions

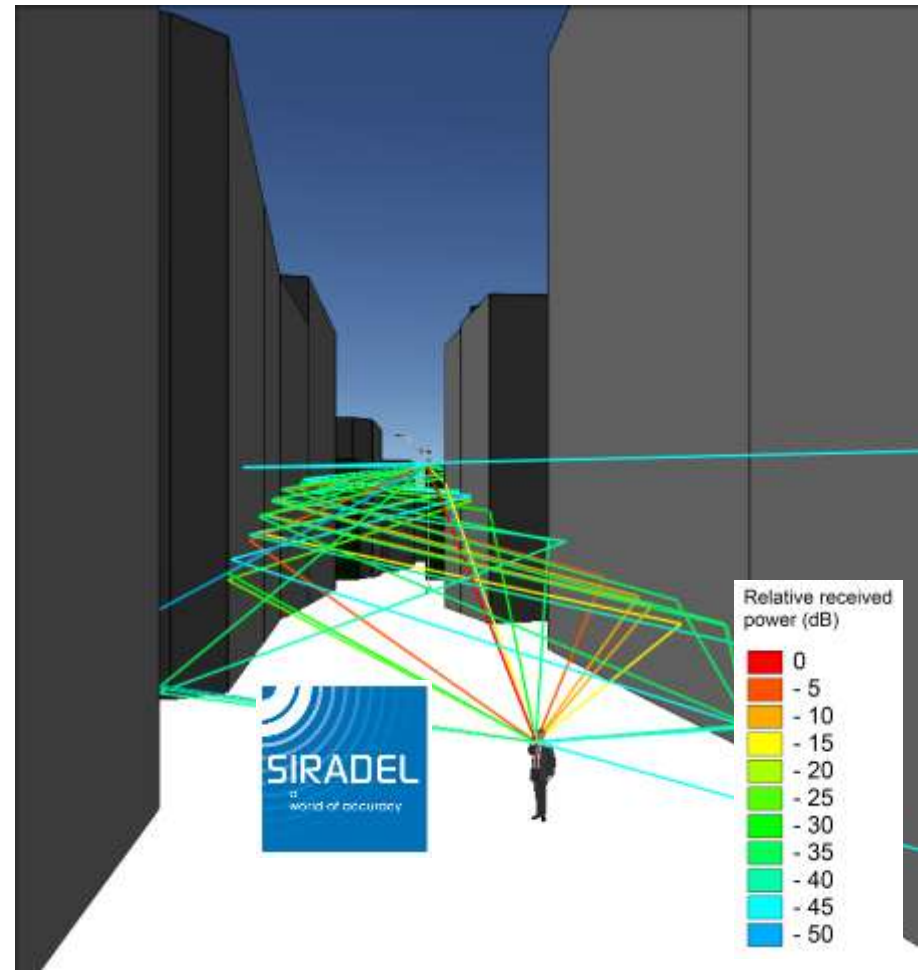
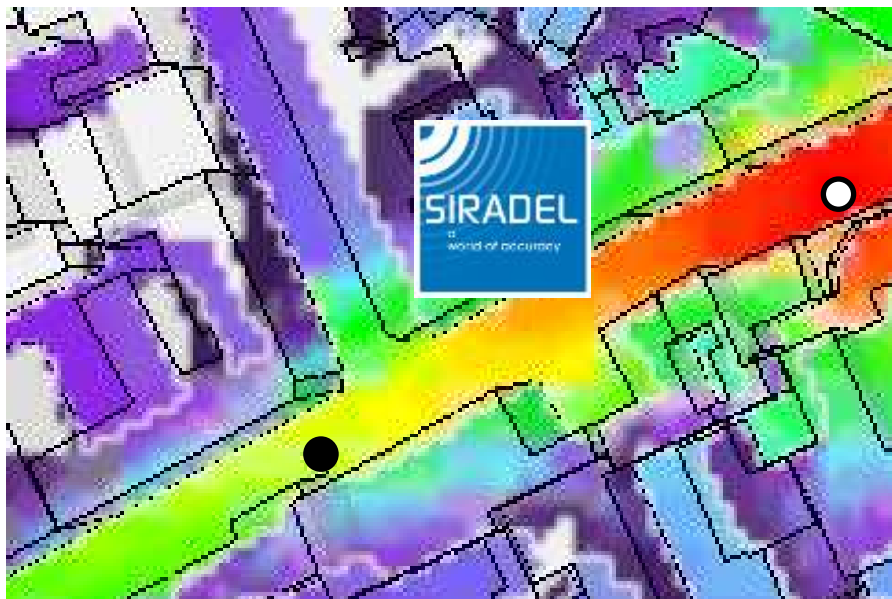


Images by Telecom Paris-Tech



and we can compute the coverage
In urban areas, multipath is important

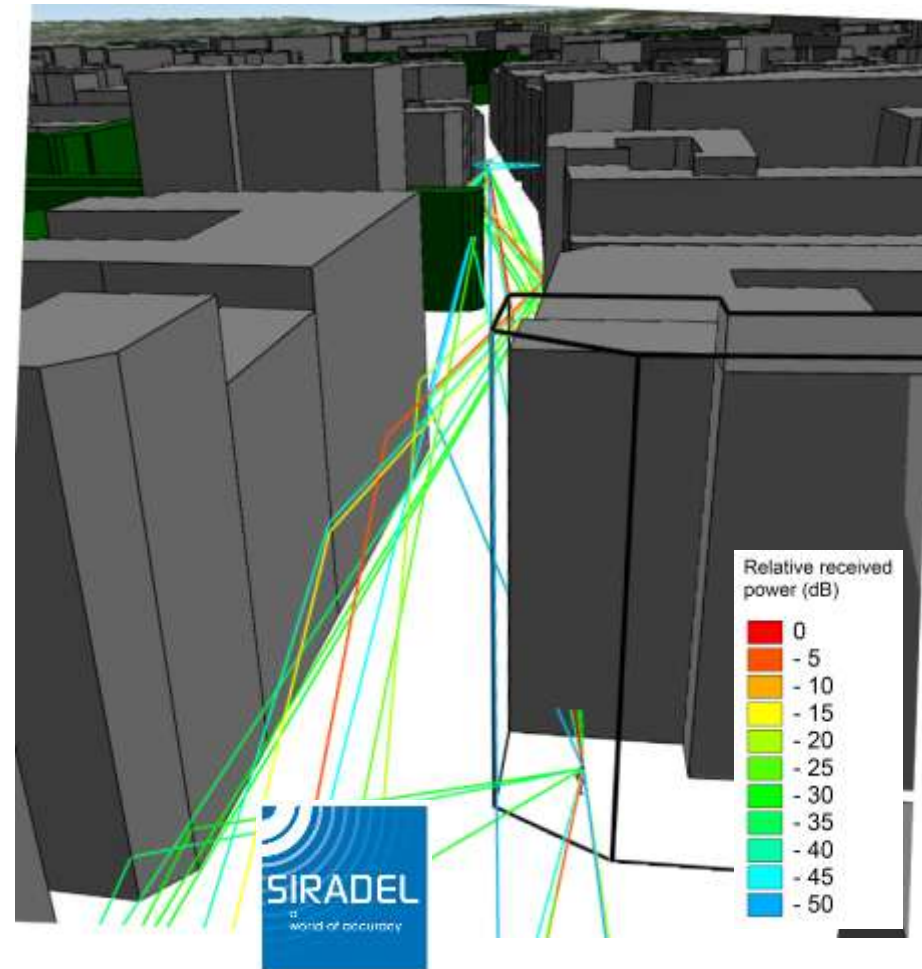
3D propagation LOS & strong canyoning



And multipath for indoor areas

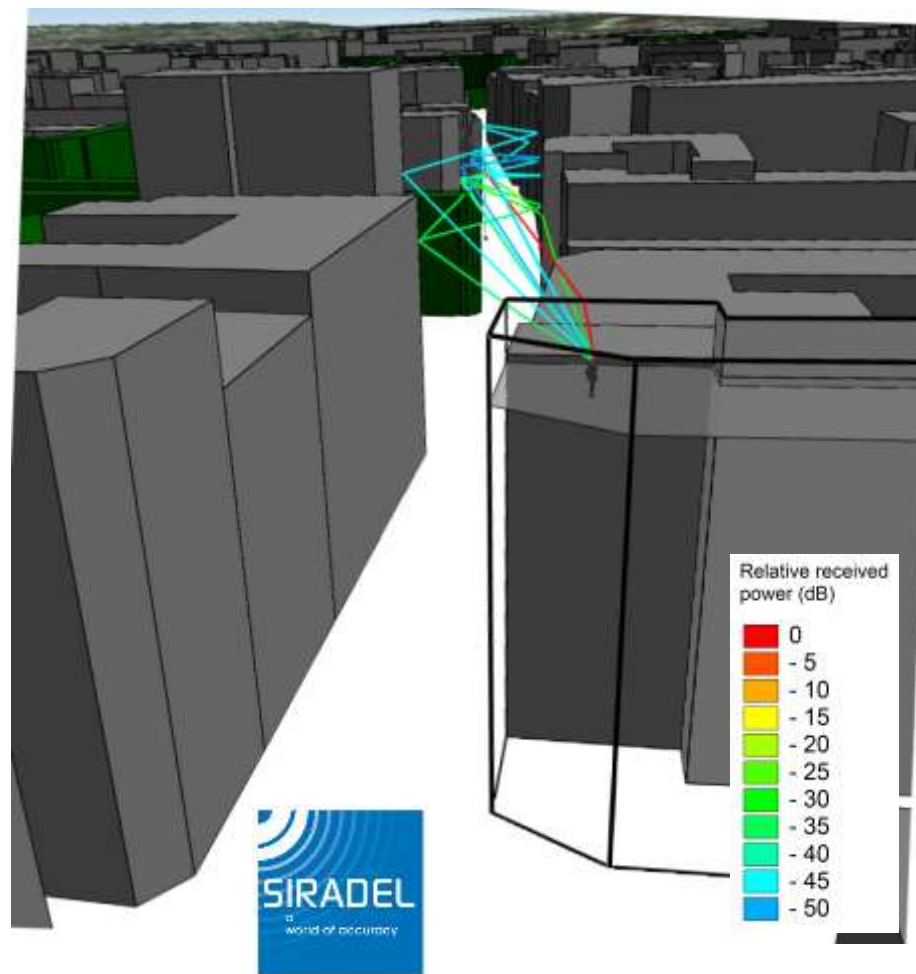
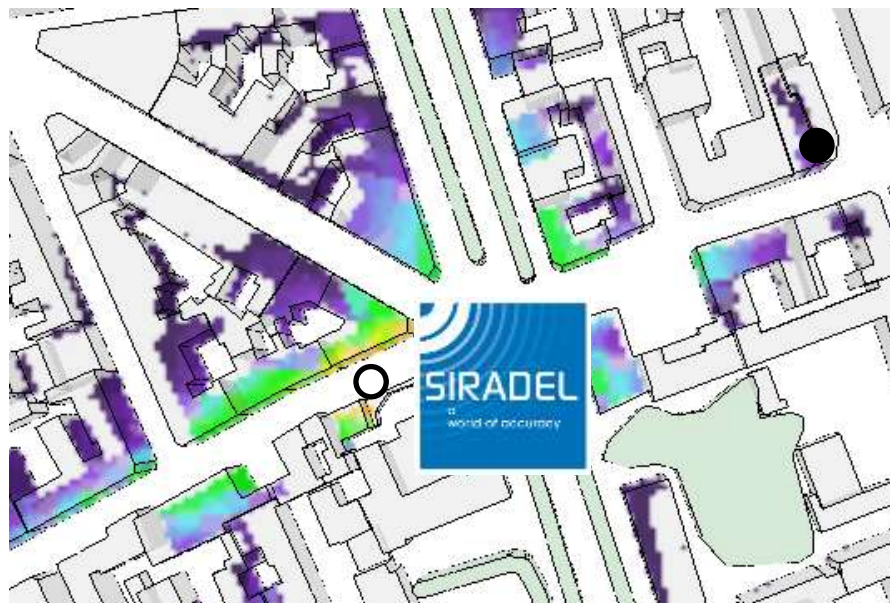
3D Indoor coverage- Ground Floor

Reception on ground-floor of a NLOS building



3D Indoor coverage – Top Floor

Reception on top-floor of a NLOS building



Multipath estimation refines the MIMO
simulation processing (space-time)...
...and is paramount for the interference
estimation

Small cell challenges

Site Location

- Traditional site acquisition: complex and expensive
- Street furniture: opportunity Optical Fiber / DSL

Interference Management

- Spectrum re-use: same or different spectrum from macro-cells
- Coordination between macro-cells and small cells

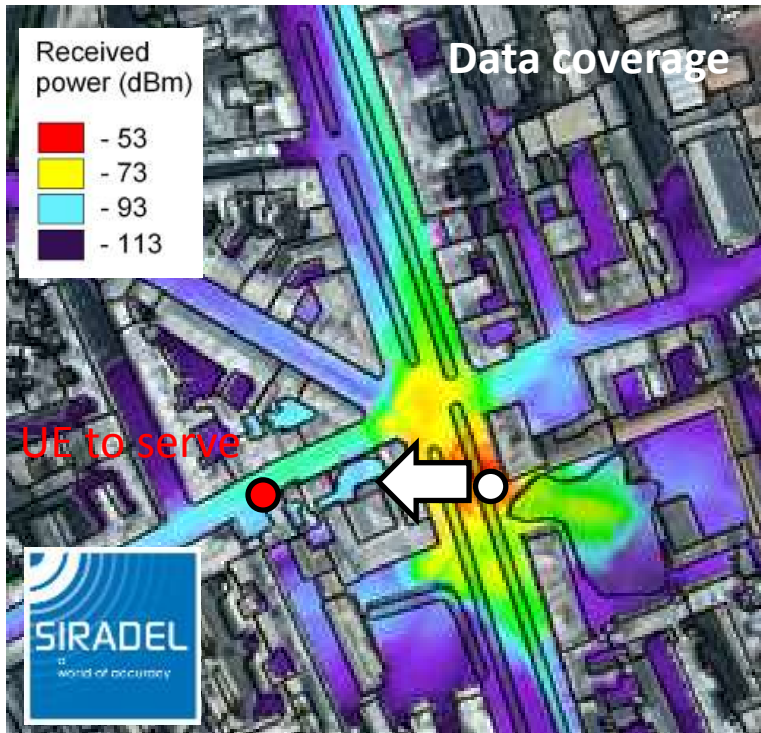
Backhaul

- Various frequency band options
- LOS and NLOS in urban areas
- Enhance flexibility in site location

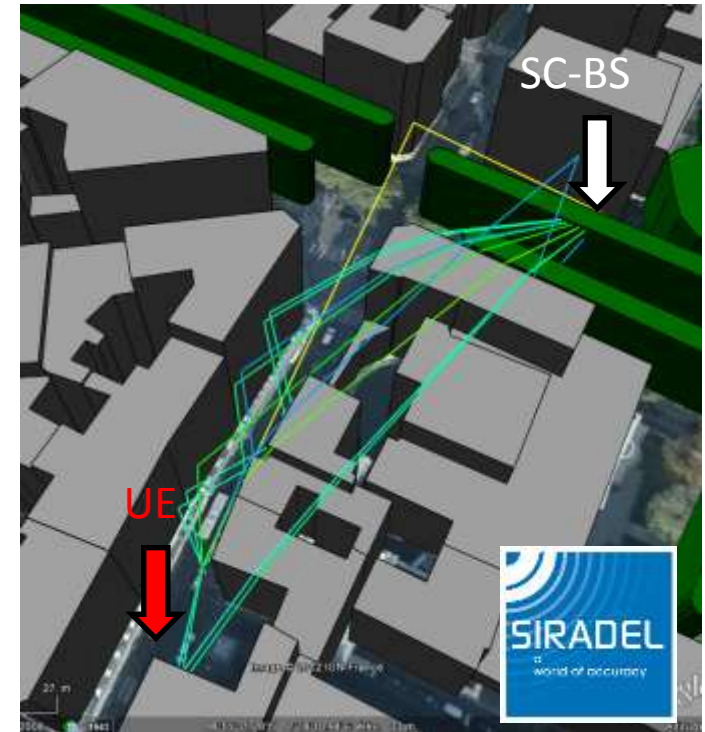
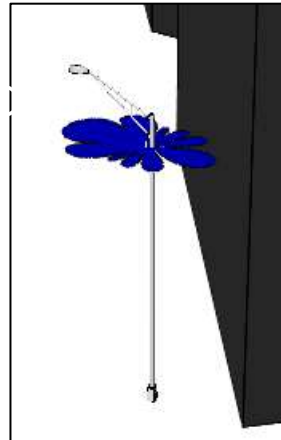


Beamforming - « Sub-optimal » Pointing

3D Antenna patterns – Antenna models
3D Propagation models
Reliable predictions for decision-making



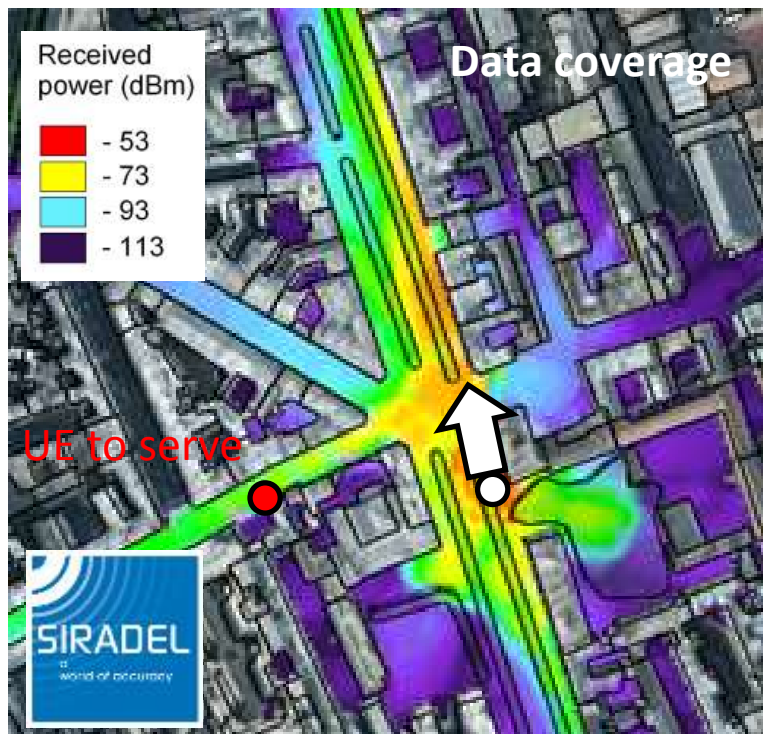
Active Antenna System



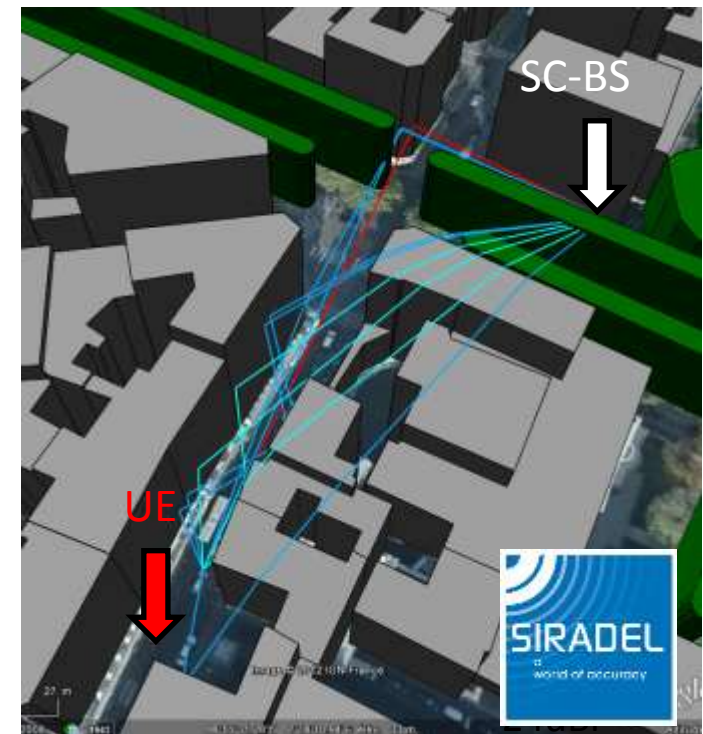
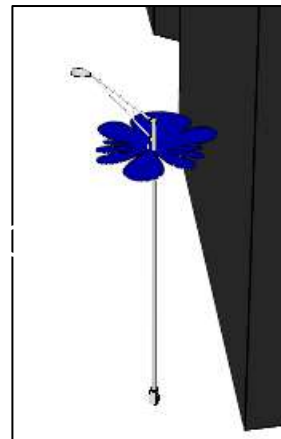
Ray-based model

Beamforming - Optimal Pointing

- Less interferences
- Less power transmitted
- Less EM radiation in undesired areas



Active Antenna System



Ray-based model

Small cell challenges

Site Location

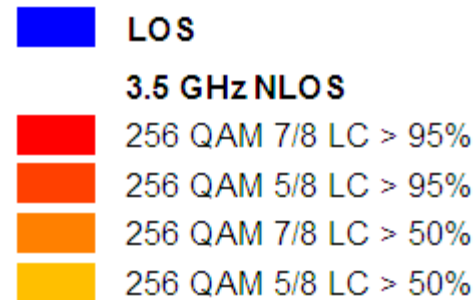
- Traditional site acquisition: complex and expensive
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Interference Management

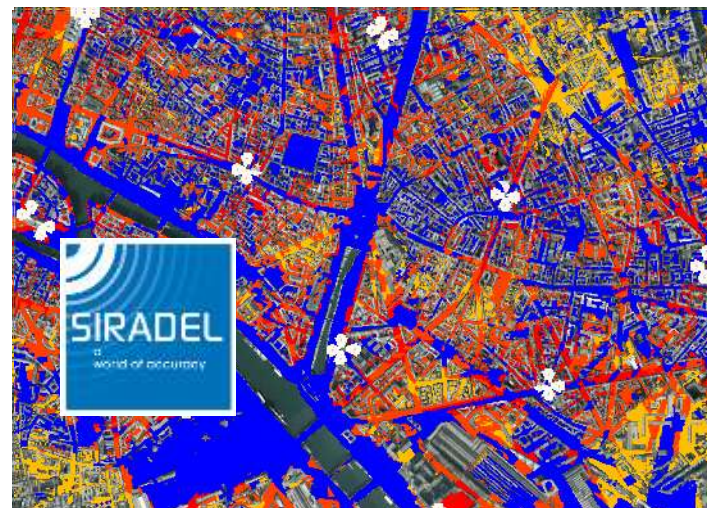
- Spectrum re-use: same or different spectrum from macro-cells
- Coordination between macro-cells and small cells

Backhaul

- Various frequency band options
- LOS and NLOS in urban areas
- Enhance flexibility in site location



SC-BS height: 20m



Outline

Context

Motivation for Hetnet

Sustainable?

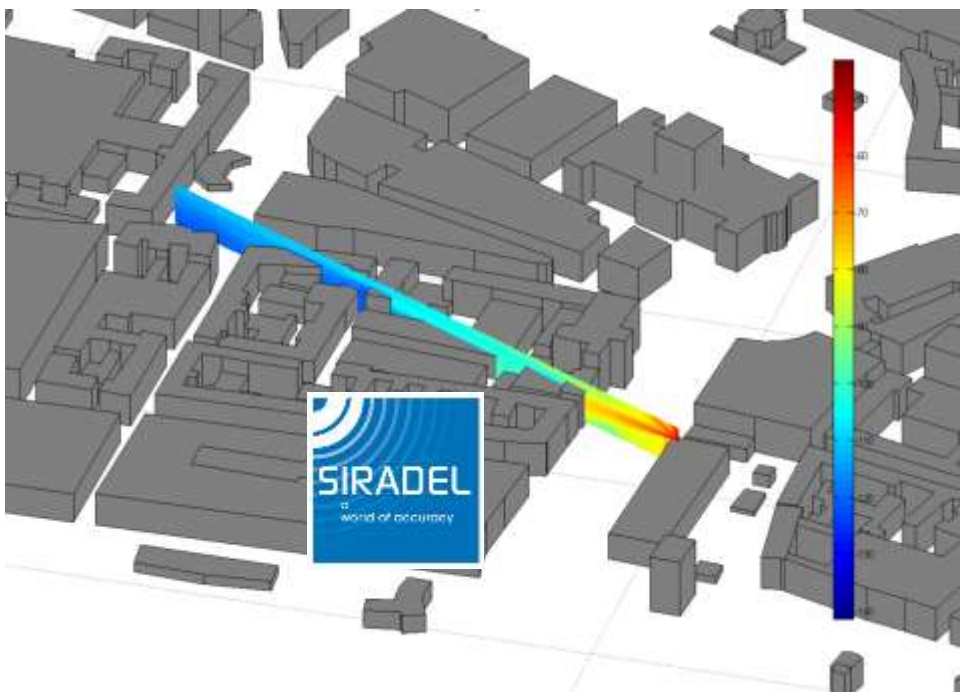
Opportunities

Great evolution of the networks to cope with
the data growth...

... but let's have a more holistic view on what
we are doing

Human exposure to EM waves

Need to better assess the radiation levels
Need to anticipate actions to optimize
Propagation and antenna tools required

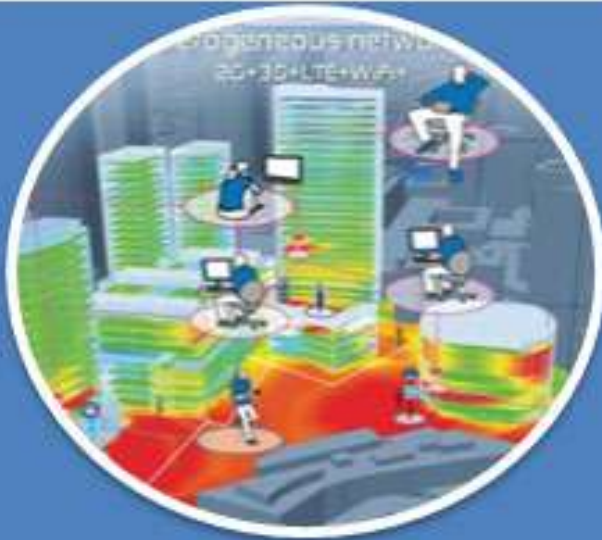


Vertical slice of Total field (V/M)



Beyond total field threshold on facades

Lexnet: EU-FP7



down and up link exposure



SAR calculations
sources, posture, morphology...

Exposure evaluation and calculation

Infrastructure will consume more energy

Energy Harvesting

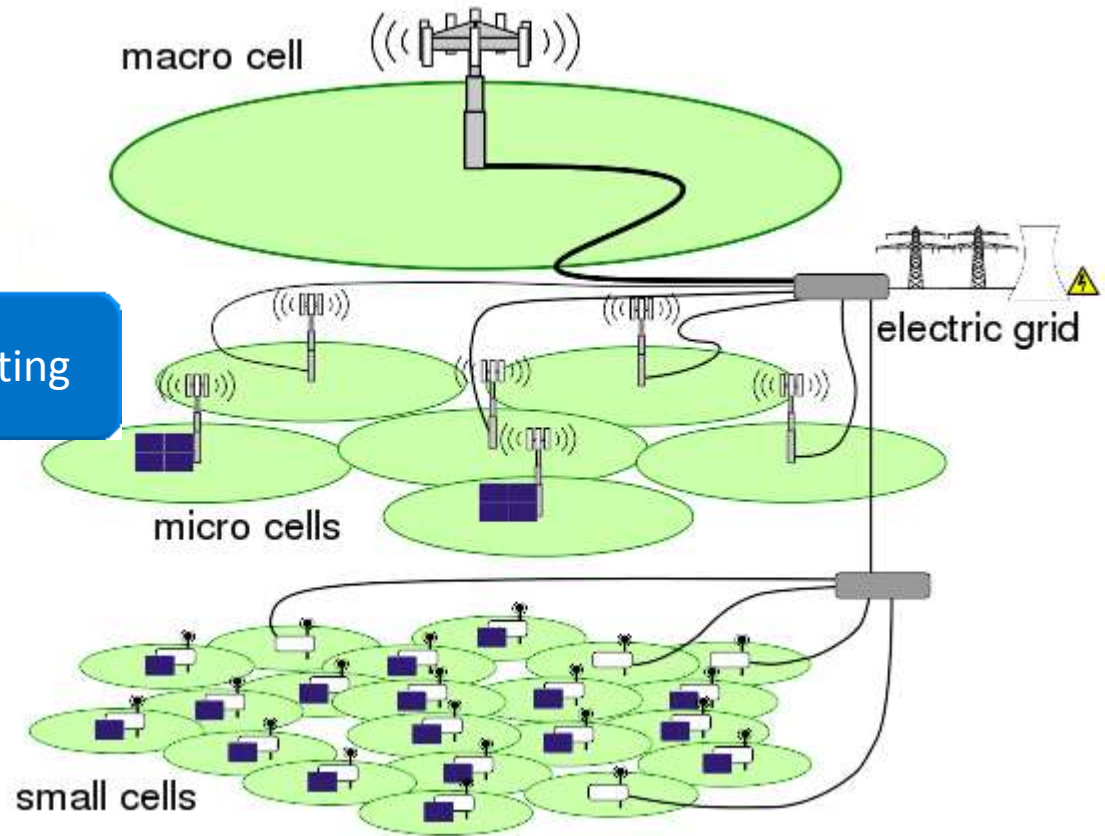


Image by CTTC

Outline

Context

Motivation for Hetnet

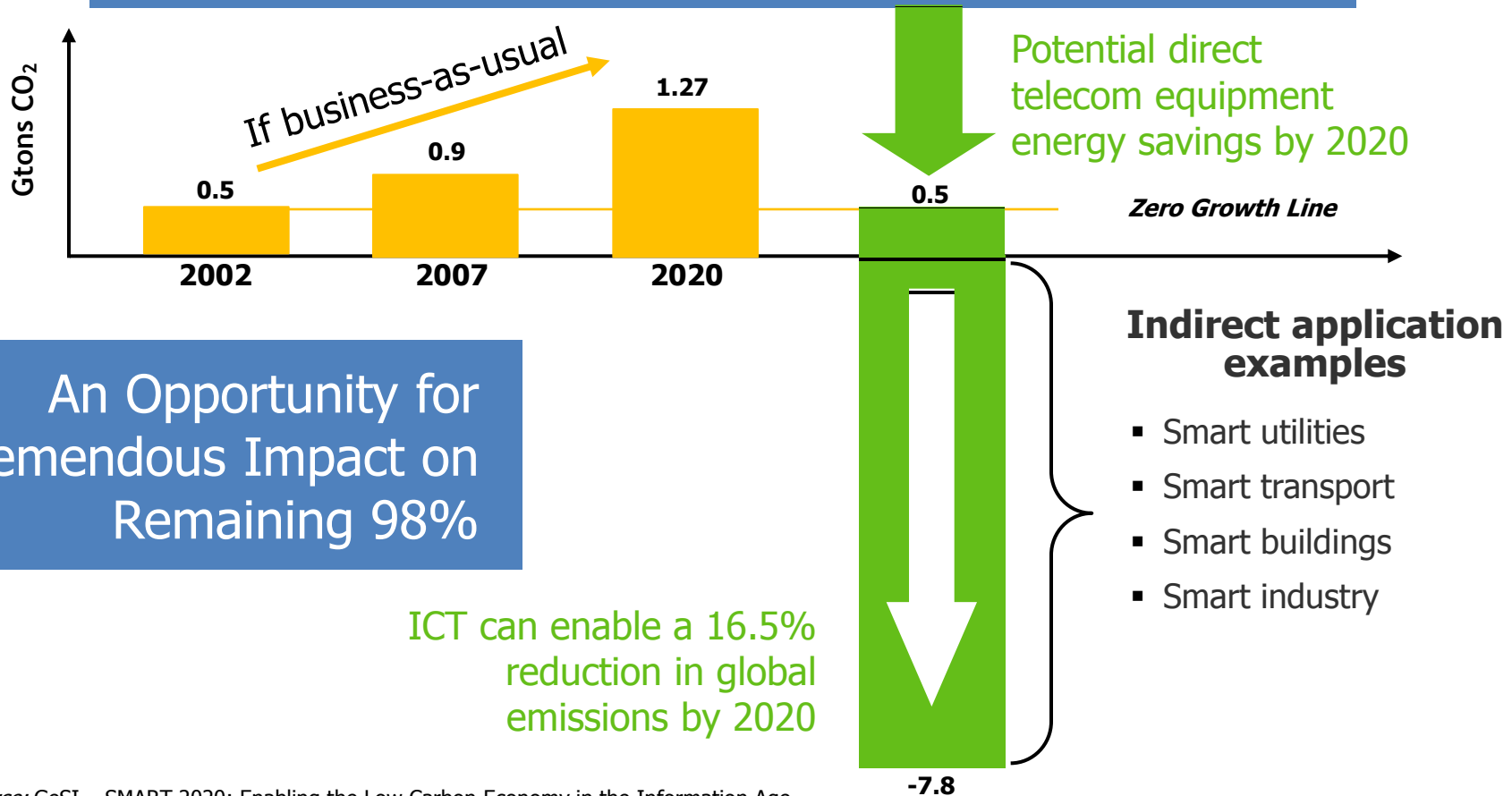
Sustainable?

Opportunities!

It may be time for a more efficient network

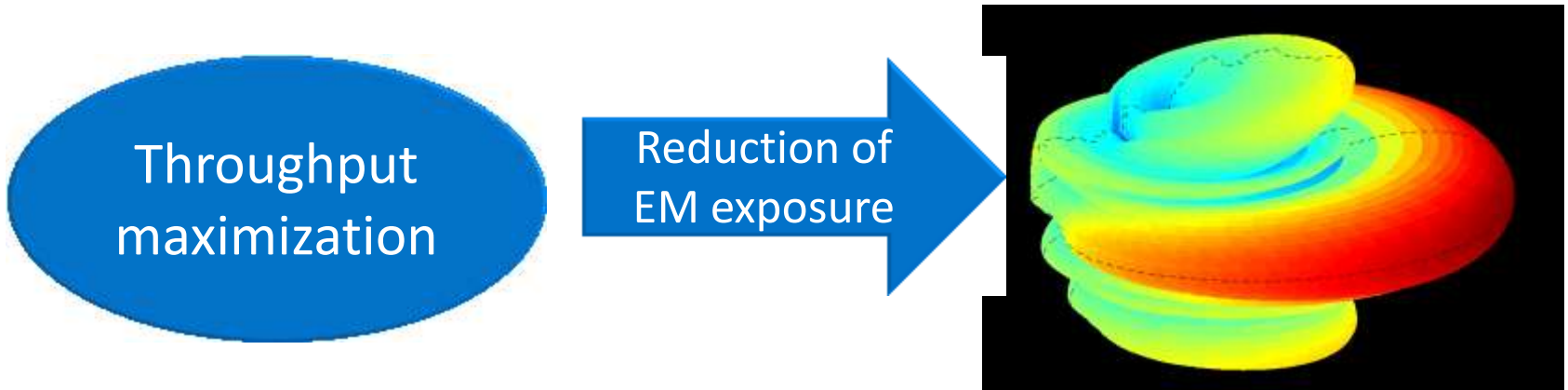
ICT: An opportunity to deal with climate changes

ICT today: about 2% of global emissions



An Opportunity for Tremendous Impact on Remaining 98%

How to get a sustainable infrastructure?

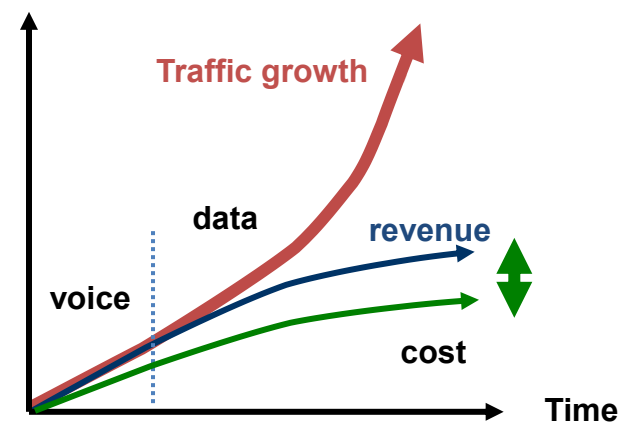
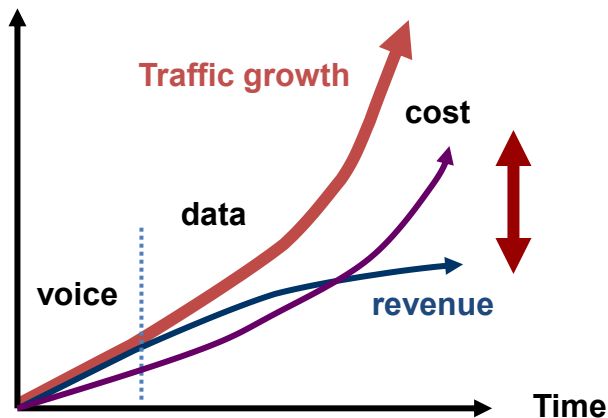


Maximization of joint efficiency while keeping equivalent UE

The infrastructure will be sustainable if it is shared among the wireless carriers

How to get long-term revenues?

- Share costs across ICT infrastructure needs
- Topologies: Reducing energy bills, site and equipment costs
- Spectrum efficiency: Taking advantage of BW
- Reduce EM waves: Need not waiting for regulation
- Anticipating massive device-to-device communications

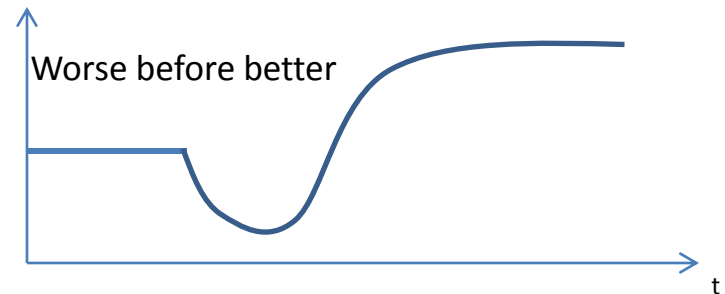
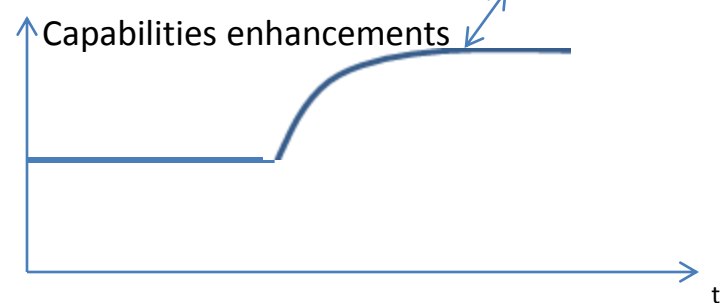
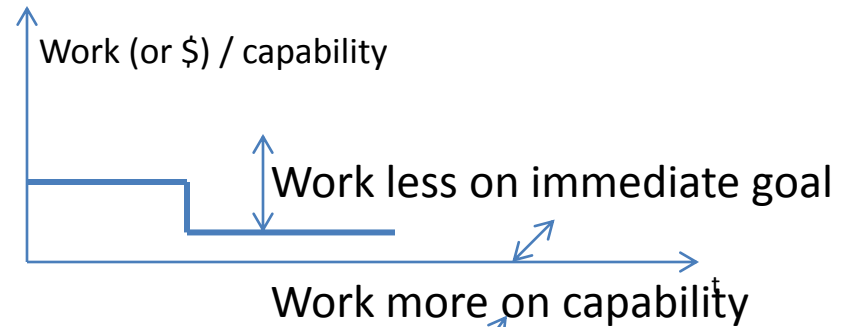


System Thinking: Worse before better

Capability trap

Capability takes time to build

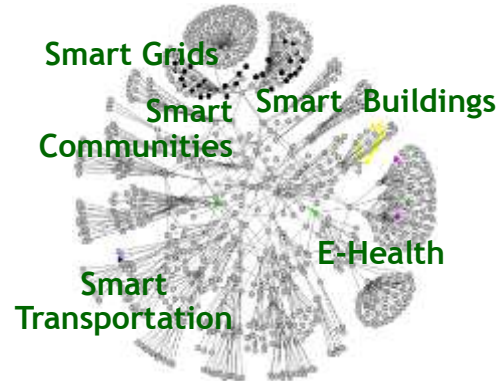
Delay in observation better performance



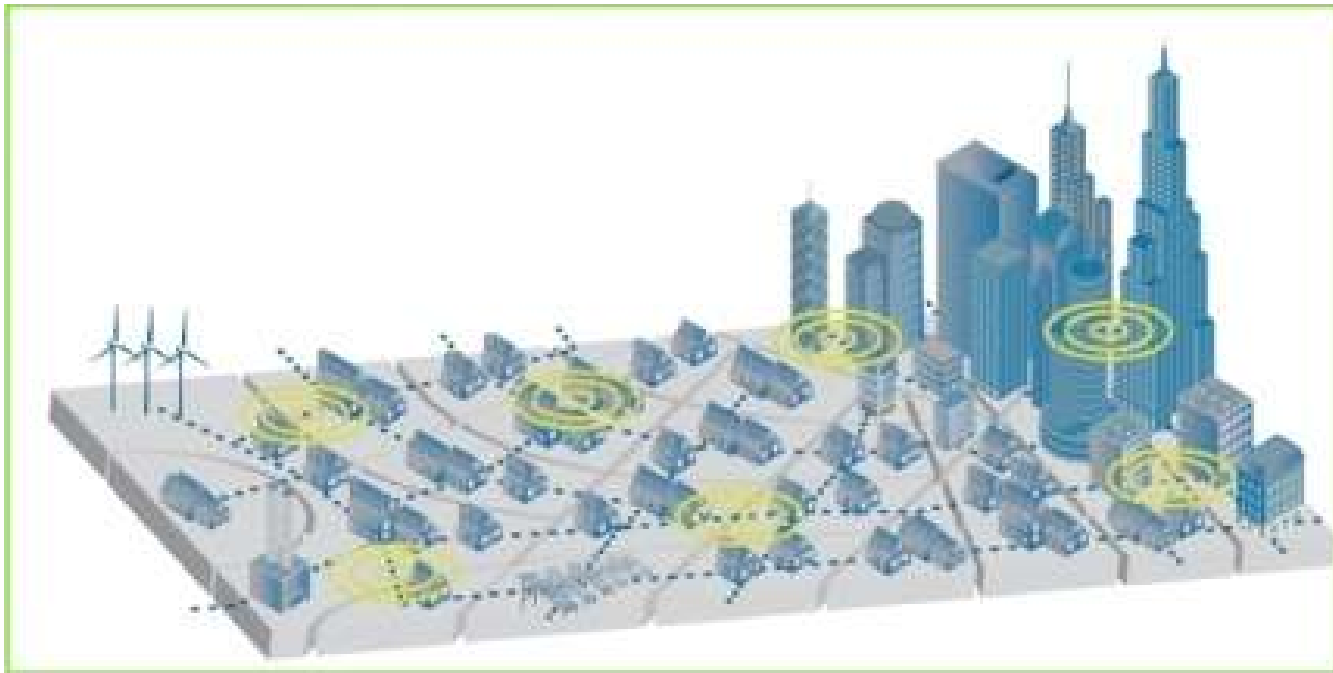
The infrastructure will be sustainable if it is shared among the various industries

Smart Cities

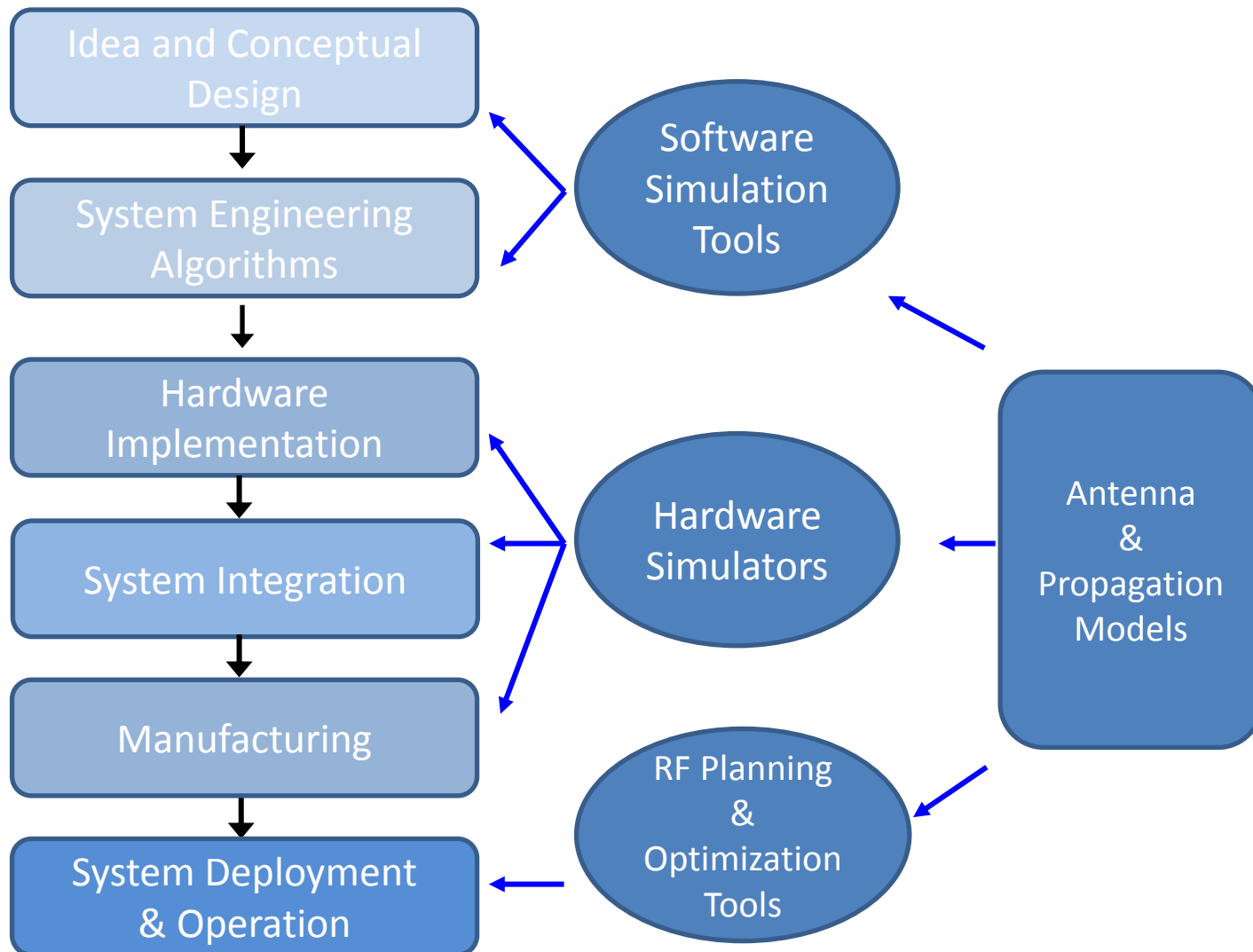
- More antennas
- Multi-relays
- Device-to-device



- Opportunity to “share”
- Joint optimizations
- Municipalities / governments



Opportunities for Antenna & Propagation **reliable** Tools



Takeaways

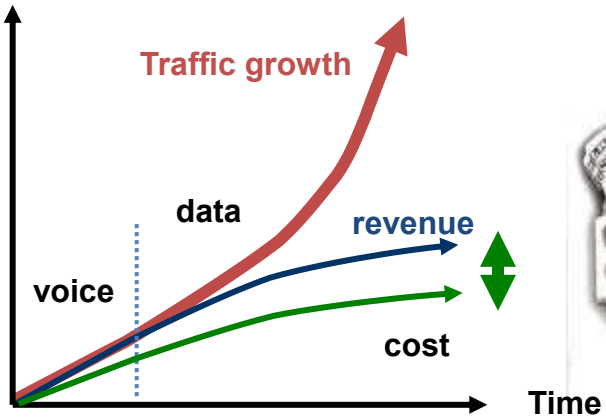
- Multi-RAT HetNet with small cells: An answer to data growth
- Mobile network optimization: shift in constraints
 - From Spectral Efficiency to Energy-efficiency and Low EM Exposure
 - ...While keeping an equivalent User experience
- Key competitive advantages in the long-run (holistic view)
- Sustainable infrastructure for Smart Cities: today's decisions
- Propagation & Antenna models and tools will help

Sustainable ICT Infrastructure

- It is a complicated task!
 - Multi-discipline
 - Multi-carriers
 - Multi-industries

Lots of learning curves

- But on the long term everyone is better off



Thank You!

