First International Summer School on Cognitive Wireless Communications

Green Ghost Femtocells

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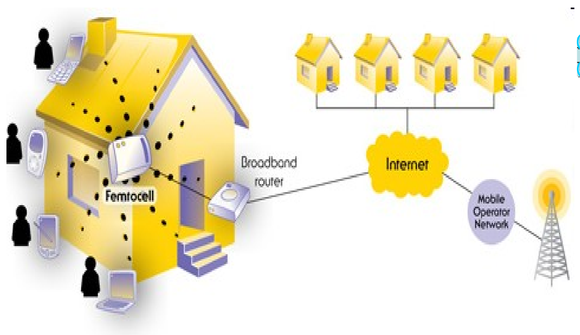
Technical Context

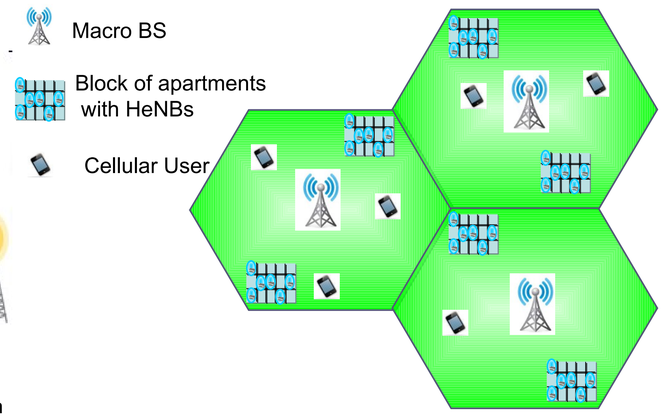
Femtocell access points (HeNBs) are low-power radio access points, classically deployed in home environment to offer coverage though a given wireless technology.

Benefits for end users:
- Better coverage
- Higher data rate
- Prolonged battery life

Benefits for cellular operators:
- Lower CAPEX
- Lower OPEX
- Enhanced users satisfaction



Courtesy of femto forum organization; www.femtoforum.com



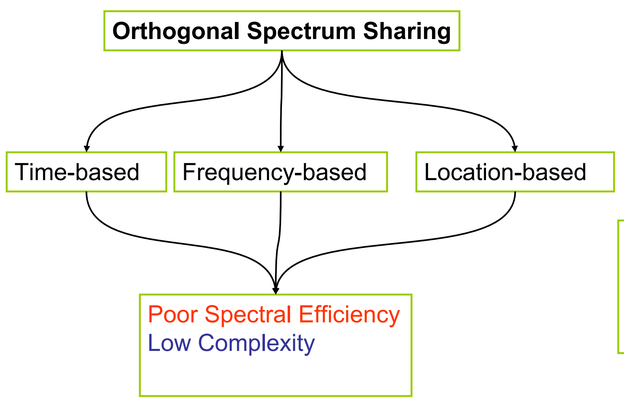
New Challenges in Two-Tier Cellular Networks:

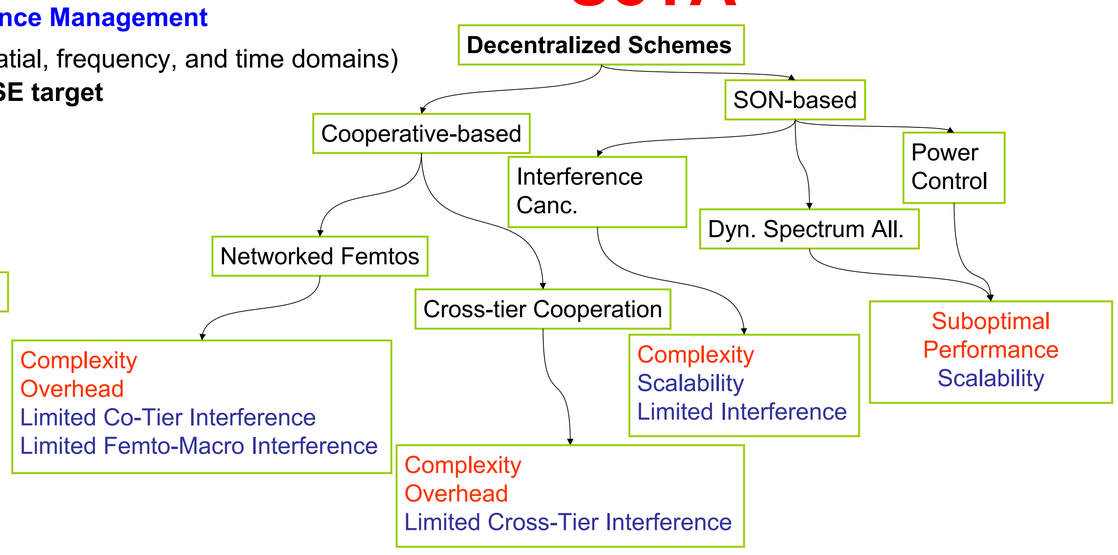
1. **Energy Efficiency**
   - **Femtocells** might reduce both the Operational Expenditure (**OPEX**) and Capital Expenditure (**CAPEX**) for cellular operators
2. **Co-Channel Interference**
   - Co-channel deployment of femtocells and macrocells rises in cross-tier and co-tier interference
3. **Deployment Efficiency**
   - Massive and uncoordinated roll out of HeNBs might increase the aggregate cellular networks power consumption

SoTA

Interference Management

- **Orthogonal spectrum sharing** approaches (on spatial, frequency, and time domains) **eliminate interference** but are **far from** operators **SE target**





Energy Efficiency with Small Cells

- Some preliminaries studies on:
1. Femtocell deployments/EE tradeoff
2. Cell size/EE tradeoff
3. Power Control effects on EE
4. Sleep Mode femtocell

- **Only RF** power consumption **is** mainly **considered** for optimization
- Few studies on **offload** impact in network **EE**
- Few studies on **Access Schemes/EE** tradeoff
- **Backhaul power model** should be investigated

"The Ghost Behavior"

Femtocells Paradigm:

- Ad-hoc nature of HeNB deployment
- Few Users per femtocell
- Short range transmissions
- Limited impact of interference due to propagation and penetration losses

- **(Time, frequency, and Power) Resources are typically under-utilized at femtocells**

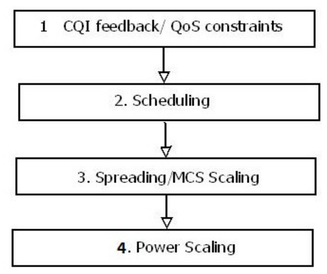
- Femtocells should **not degrade concurrent transmissions** of neighbour cells
- **Self-organized** approaches are **preferable** because of the limited capacity of **backhauls** and **complexity** constraints
- Smartly '**waste**' available **resources** to efficiently **underlay** transmissions of neighbor cells

The Ghost RRM Algorithm

1) Users feedback to their HeNBs CQI measurement and QoS constraints

2) Each HeNB schedule its UEs according to the received feedback

3) HeNBs smartly profit of further available RBs to spread their data



4) Finally, we apply techniques based on **MCS scaling** to tradeoff transmission **energy for frequency** resource

Simulation Results

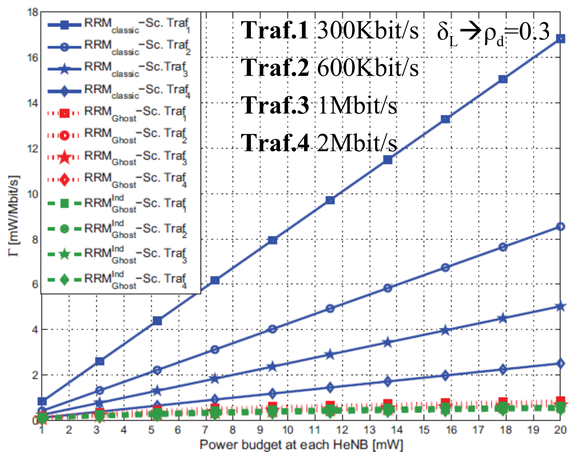
The 3GPP Femtocells grid urban deployment model:

- 10 m x 10 m apartments are placed into a 5x5 grid
- Deployment ratio ρ_d
- Activation ratio ρ_a
- Outdoor wall attenuation (20 dB)
- 5 dB of loss due to walls within the grid of apartments
- Loss to walls inside each apartment are modelled as a loglinear value equal to 0.7 dB/m

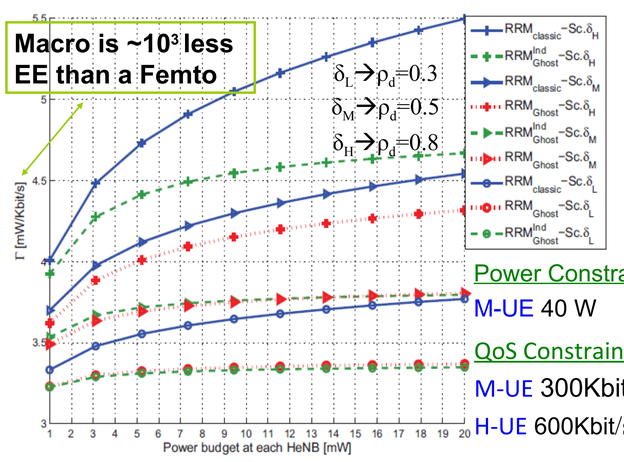
Investigated Algorithms:

- In both $RRM_{classic}$ and RRM_{Ghost}^{Ind} is **no coordination** between neighbour femtocells;
- In RRM_{Ghost} neighbour femtocells **coordinate the access** to the spectrum to **reduce co-tier interference**
- $RRM_{classic}$ aims at maximizing the spectral efficiency of femtocells while minimizing the probability that neighbour UEs access to same RBs. **Thus, the $RRM_{classic}$ attempts to limit the number of Rbs allotted to each H-UE**;
- $RRM_{classic}$ does not implement **MCS and Power scaling**

Femtocell Average Transmission Power over Throughput



Macrocell Average Transmission Power over Throughput



Power Constraints:
M-UE 40 W

QoS Constraints:
M-UE 300Kbit/s
H-UE 600Kbit/s