Energy-Efficient Hybrid cellular networks
Réseaux hybrides à haute efficacité énergétique

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29 juin 2012
Plan

- 1- Context and definitions
- 1a- Normalization and commercialization
- 2- Objectives
- 3- Model and problem description
- 4- State of the art
- 5- Our Work
1- Context

- Energy Constraints: energy contribution of ICT is XX % of the global energy consumption (Gartner, 2007)
- Mobile Data traffic increase: x2 every year or two years according to different sources \( \rightarrow x1000 \text{ in around 15 years} \) (but who will verify in 15 years?)

- Source Fig.: Rit12, Projet Greentouch
1- Context

- More research has to be done to ameliorate spectrum efficiency but much has been already done: modulation, coding, radio procedures (ex: HARQ in Layer 2).
- Recommended Survey:
- New approaches needed. Most of these approaches can be summarized in a few words: put the transmitter closer to the receiver!
1- Context: generations of cellular systems

- Start of commercialization for different generations of cellular networks (approx):
  - 1G: 1979 (Japan)
  - 2G: 1991
  - 3G: 2001
  - 4G*: 2010
    *3.9G for purists … Marketing: 4G
  - 5G: no name available*, no initiative
    * 3G: IMT-2000 or UMTS was known as FPLMTS
1a- Normalization and commercialization of small cells

- By Definition a **femtocell** agnostically refers to a small wireless base station or access point.

- This small element of wireless infrastructure is generally **intended to quickly and inexpensively extend the wireless coverage and capacity in an indoor environment.**

Source Fig: Femto Forum
(www.femtoforum.org)
1a- Normalization and commercialization of small cells

- Standard Handover between micro or macro cells and Femtocells

Source Fig: Kineto Wireless and Femto Forum (www.femtoforum.org)
1a- Normalization and commercialization of small cells

- Commercialization of small cells:
  - Orange Femtocell offer expected in the first part of 2013.

- “China Mobile is already deploying 3G femtocells, initially using the 3G standard TD-SCDMA, and later TD-LTE too” (Rethink Wireless Site, may 12)
2- Small cells

- Macro cell: classical, well-known
- "small cell": many definitions …
  - Micro
  - Pico \((10^{-12})\): outdoor, operator-installed for hotspot, Power order of magnitude: 100 W
  - Femto \((10^{-15})\): indoor, user installed (DSL evolution?), Power order of magnitude: 40 W
  - Attocell \((10^{-18})\): connection between a laptop and a smartphone, includes software for original operator association (needs operator agreement)
2- Small cells: Objectives

- Objectives of different types:
  - increase access network capacity;
  - operator economies (possibly!);
  - extension of coverage;
    (recently)
  - energy economies
2- Small cells

- **Top-two (by far) references:**
2- Small cells: how to get closer to the user?

- Illustration of the new cell layout
  (Figure Source: ALU, Pracom Seminar, June 12)
- Possibility: dynamic change of the cell size, See PhD of Luis A. Suarez
2- Small cells

- New cell sizes $\rightarrow$ new interference issue
- Fig. Source: Kountouris, Green Radio Day, ISIS Seminar, June 12
3- Model and issues

- Interference between macro and small cells;
- Position of small cell: random or deterministic? Optimized?
- Why will a subscriber accept to turn his modem ("box") into a femtocell?

- Problem Formulation: TBC
4- State of the art

- Claussen et Al [2008]: hybrid macro/pico-BS cellular network environment.
  - Estimation of energy consumption reduction and coverage enhancement
  - Effect of sleep mode.

- Micaleff et Al [2011]: study of growth strategies for an access network.
  - Comparison of macro-only and hybrid macro-pico environments in a four-year evolution (interesting economic model).
4- State of the art

- F. Cao, Z. Fan [2010]: Hybrid macro/pico-BS cellular network environment.
  → Estimation of energy consumption reduction.

- W. Wang, G. Shen [2010]: Hybrid macro/pico-BS cellular network environment.
  → Estimation of energy consumption reduction for different densities of picocells installed.
  More picocells = increase of capacity but also more energy consumed.
  → Existence of optimal picocell density.
  → Effect of macrocell intersite distance on the observed indicators.
4- State of the art

- **Adapted Resource Allocation algorithms:**
  References [5][6][7] intend to mitigate the interference produced in downlink or uplink, whether by MacroBS and associate MUEs on a femtoBS and the associated HUES and vice versa by proper radio resource allocation algorithms: bandwidth partitionning or sharing, …
Femtocells provide energy economies in some cases and if they are:
- properly dimensioned and positionned,
- shut down whenever possible (→ our work: trying to say when!).

Figure source: Rittenhouse, ALU, April 2012
5- Our Work

- Extend Cell Breathing analysis (/* see 2 recent papers) done for macro cell to Hybrid Networks (PhD work of Luis)

- When to wake-up small cells (same question for macro)? Possible model elements:
  - Include proposal of reverse-paging message, Alberto Conte, ALU, and colleagues from FP7 TREND Project*
  - Use LTE X2 interface between base stations to have one BS (normally macro) wake up another BS (normally small)
  - Use the mobiles GPS

- Specific LTE-A environment
References


