

Small Cells and the Mobile Broadband ecosystem

Miquel Oliver, miquel.oliver@upf.edu
William Lehr, wlehr@mit.edu

Euro ITS Conference
Brussels, June 2014



Universitat
Pompeu Fabra
Barcelona



Massachusetts Institute of Technology

- Motivation
- Small cells: definition, scenarios, status
- Challenges and Implications
- Conclusions

- Some facts about Mobile traffic:
 - Exponential growth: 81% in 2013 (Cisco VNI)
 - Personal usage (4G/WiFi): 22% / 78% of traffic*
 - WiFi drives now most of the “mobile” traffic
- How to address the exponential growth of Mobile Broadband traffic?
 - Looking for more spectrum, or changing its management, or both
 - Improving the wireless technology (LTE Advanced, MIMO, 5G)
 - Spatially reusing frequencies: **small cells** provide “unlimited” capacity for growth

- What is a Small Cell?
 - Low-power (20-100mW),
 - Limited-range ($< 100\text{m}$),
 - Variable data rates (10-100⁺Mbps)
... base stations or access points
- Current implementations for small cells:
 - 3G/4G cellular family: micro/pico/femto cells
 - IEEE802.11 family for WLAN (WiFi)

Why smaller cells?

- Spectrum scarcity: spatial reuse
 - Unlimited increase in capacity
 - Higher mobility becomes an issue
- Coverage & Capacity hot spots
 - In-home (rural) dead zones
 - High-density traffic areas
- Power conservation
 - Power/range related
- Market evolution/Technical progress
 - Demand growth → always on, everywhere, richer services
 - Technology → faster, smaller, cheaper; HetNets; convergence WiFi/LTE

WiFi and Femtocell trajectories

	WiFi	Femtocells
Technology -- Spectral efficiency -- MAC -- Power mgmt. -- Channel flexibility -- Network planning	802.11 WLAN -- Efficient, MIMO support -- Distributed CSMA/CA. Weak support when multiple AP, nomadic mobility -- Constant power -- Larger, shared channels and channel bonding -- Self-configured	3G/4G (LTE) 3GPP -- Efficient, MIMO support -- Centralized. Strong coordination among base stations, fast mobility support -- Fine-grained highly dynamic -- Channel aggregation, dynamic bandwidth allocation -- Critical to manage interference/coordinate APs
Spectrum	Unlicensed	Licensed
Capabilities/capacity	Improving at Gbps (802.11ac)	Improving at Gbps (LTE rel 12)
Hardware	Commodity	Operator custom
Installed base	Huge	Emerging
Deployment model	End-user, single AP	Carrier, integrated

Figure 2: Summary Comparison of WiFi and Femtocell Technologies

WiFi v. Femtocells

- 4G/LTE is more recent and with less penetration:
 - LTE has limited coverage (20% population in 2013) and low adoption rates yet
 - The largest LTE market is in the US with 100M subscribers (2013)
- Current deployments:

	WiFi	Femtocells
Scenario A (in-house)	439	4.8
Scenario B (hotspots)	1.3	1.2
Overall base installed	440.3	6

Figure 4: Global Deployments of Small Cells as of 2012 (millions)⁵⁷

- Smalls cells open many challenges and implications. We highlight three of them:
 - Fixed-mobile convergence: help drive fixed-mobile convergence
 - **End-user empowerment:** enable end-user control and provide a new vector for last-mile competition
 - Spectrum management: propel the movement to unlicensed and dynamic spectrum access

Small cells implication: End-user empowerment

- More active role in provisioning, and potentially controlling, broadband services
 - In most cases end-users purchase, own the small cells, provide power and location as well as backhaul services
 - Impact on capital and operational costs
- A significant volume of traffic is offloaded traffic from mobile networks
 - Between 1/3 and 2/3 of mobile traffic is offloaded to WiFi

Small cells implication: End-user empowerment

- Wireless: new vector for value creation, facilities competition
 - APs: end-user controlled
 - Backhaul: community (municipal networking)
 - Internet of Things and local services
- Benefits?
 - Uncork last-mile bottleneck: response to NN concerns.
 - End-user autonomy/Freedom: choice,
 - Edge-based innovation: decoupled, local, viral
- Problems?
 - Source-based routing: unbundle ISP offers/optimization?
 - End-to-end QoS/Reliability: fault assessment?
 - Coordination? Harder roaming
 - Interoperability, connectivity suffer?
 - Open standards (WiFi and LTE) as a response

But this is just the beginning of the story ...

- Are small cells going to disrupt the broadband market?
- Small cells drive mobile-fixed convergence: how the backhaul is provided?
- Empowering end-users: a new vector for competition?
- Small cells may even affect how spectrum is shared tilting the balance in favor of unlicensed

We envisage a more hybrid technical solutions for small cells, combining WiFi and Femtocells

Small Cells and the Mobile Broadband ecosystem

Miquel Oliver, miquel.oliver@upf.edu
William Lehr, wlehr@mit.edu

Euro ITS Conference
Brussels, June 2014



Universitat
Pompeu Fabra
Barcelona



- Fixed-mobile convergence

Implications	Fixed Broadband	Mobile Cellular
Regulatory burden ⁷¹	Regulated last-mile, Net neutrality, legacy natural monopoly	Less regulated, more competitive from start.
Retail/customer contact	Per household. Aggregates traffic of multiple customers.	Per user. Follow-anywhere, customized
Access? (local backhaul) ⁷²	In-house wiring. Last-mile.	In-house wiring. Wireless last-mile limited.
Backhaul availability ⁷³	Wide-area network	May have wide-area network or not.
Spectrum ⁷⁴	On-the wire or fiber. Unlicensed	Licensed Unlicensed (potentially)

Figure 5: Legacy Fixed v. Mobile Broadband



Fixed-mobile convergence



- Drivers need to integrate networks, enabling platform competition
 - Mobile and fixed BB have differentiated, complementary features
 - Platform competition: fixed/mobile, WiFi/3G-4G
- Coverage, capacity → demand:
 - Demand price substitutes
 - Potential for supply substitution
- Small cells → wired backhaul (FTTH driver)
 - Fixed provides own wires
 - Community-provided solutions
 - Nomadic v. Mobile solutions: offloading
- Interconnection: Fixed/Mobile providers
 - Who owns the customer? Backhaul costs recovered?
 - New ISP peering model?

- Sharing models: frequency/geo/time/code/angle/...
 - Coordinated/uncoordinated: licensed bands
 - Licensed/unlicensed: interference protection rights
- More granular/dynamic/local resource management:
 - Dynamic Spectrum Access: smart radios
 - Spectrum sharing among users/uses
 - More commercial spectrum for mobile BB: licensed, unlicensed
 - Flexible/adaptive: future-proof regulatory process



Massachusetts Institute of Technology



Acknowledgements



- NSF Awards 1040020, 1040023 and the MIT Communications Futures Program
<http://cfp.mit.edu>
- Spanish Ministry project TEC2012-32354 and the ANA Group @CSAIL/MIT