Femtocells: implementation challenges and solutions

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Airvana at a Glance

A Mobile Broadband Leader

All IP wireless networks (RAN) leader
- Full EVDO product line

- Fixed Mobile Convergence (FMC) pioneer
  - Universal Access Gateway
  - Personal Base Stations (Femtos)

- Key Standards: EV-DO, UMTS & 4G

Market Channels

Deployed by over 30 global operators

- QUALCOMM
- NORTEL
- Alcatel-Lucent
- Sprint
- verizon
- alltel wireless
- Telefonica
- Eurotel
- Bell
What are femtocells?

- A femtocell network is a cellular network taken to its logical extreme
- Cell sizes as small as possible.
- Network capacity (bits/second/Hz/square meter) maximized

Microcell coverage: Several blocks
Active users: 40

Macrocell coverage: Several km²
Active users: 40

Femtocell coverage: Large house
Active users: 4-6

Picocell coverage: Large hall
Active users: 10-20
Femtocells: value proposition

- Reduced Propagation Loss $\rightarrow$ Higher SINR
- Dedicated Sector Capacity for Every Femto Home
- Dedicated backhaul for every home
Femtocell: Carrier expectations summary

- Don’t want femtocells, want an end-to-end solution
- Quality/reliability comparable to macro systems
- Easy to deploy and manage
- Cost/subscriber comparable to that in macro network
Femtocells: Technical challenges
Timing and synchronization

- GPS/Assisted GPS
  - When GPS signal available

- Macro `Sniffing`
  - If Macro signals detectable @ Femto

- Free running
Deployment: Shared spectrum/dedicated spectrum?

- Where unused spectrum is available
  - Suburban and rural areas

- Where unused spectrum is not available
  - Urban areas
Shared spectrum: interference challenges

- **Femtocell Near Macro Cell Edge**
  - Femto degrades macro on FL
  - Macro user overloads femto in RL

- **Femtocell Very Close to Macro Cell Site**
  - Macro degrades femto on FL

- **Femtocells With Overlapping Coverage**
  - Femtos degrade each other on FL
  - Femto users degrade other femtos in RL
Potential solutions to interference

- Intelligent network planning (frequency, PN allocation)
- Continuous learning about environment
- Intelligent transmit power setting (cell sizing)
- Mitigation by adaptive power/rate control
- Redirecting problem users to macro
User migration between femto/macro

- Idle-mode “rove-in”
- Idle-mode “rove-out”
- Active mode hand-in
- Active mode hand-out
- No assistance from legacy handsets
- Need integration in some form with legacy networks
How to attract users on other frequencies?

F1  F2  F3
Macro Femto

Pilot, Control Channels Redirect Msgs

Beacon
Operational

Time
Access control

- All mobiles in range are attracted from macro frequencies.
- Everyone is allowed to camp & make calls.

- Only authorized users are attracted from macro frequencies.
- Unauthorized users redirected to macro.
- Emergency calls permitted.
Femtocell network architecture
Backhaul

• Femtos expected to use public internet to connect to the operator’s cellular core
  ▪ DSL, Cable, FIOS
  ▪ Backhaul not in operator’s control.

• No guarantee of quality
  ▪ Time-varying delays, jitter

• User-perceived quality has to be managed
  ▪ Adaptive de-jitter, intelligent buffering…
Network security

• Operator’s wireless core networks are typically not designed to be open to the world

• Femtocells connect to the operator’s core through the public internet

• “Security Gateways” or “Access Gateways” serve as firewalls between femtos and operator’s core

• Femtos get into the core through IPSEC tunnels established with the Security Gateway
Security tunnels

- Authenticating the femtocell
  - SIM cards, certificates
Other security considerations

• Femtocells should be allowed to radiate only in a given geographic area
  ▪ Tie femto to unique IP address
  ▪ Tie femto to GPS coordinates

• Femtocells should be hacker-resistant
  ▪ Potential for use as highly efficient jammer
Interface to the core network:

- Three distinct approaches:
  - Tunneling the RNC/MSC interface to a traditional MSC
    - Iu over IP (GSM/UMTS),
    - IOS over IP (CDMA)
  - SIP/IMS to the core
  - IMS/IOS hybrid
Iu tunneling (UMTS)

Iu Concentrator: proxy RNC function
IMS Core (CDMA example)
Future directions

“De-coupled” Hybrid Networks

Works with Existing Handsets & Existing Macro Network

2008-2010

“Cooperative” Hybrid Networks

New Femto-Aware Handsets
Femto-Aware Macro Network

2010+

- Closed Subscriber Groups
- Preferred User Zone List (PUZL)
- Hand-in Enhancements

Standardization
Management & Provisioning
Femto device management: high-level aspects

- Automatic provisioning
  - Unique to femtocells
- Network health monitoring
- Performance data collection
- Remote diagnostics
  - Bad backhaul? Bad SNR? Too much backhaul delay?
- Remote software upgrade
Automated Network Planning

- Automatic generation of femtocell configuration
  - Femtocell environment measurements
  - Macro network data
  - Operator configuration

- Monitors macro network data for changes that impact activated femtocells

- Dynamically updates femtocell configuration
Troubleshooting & diagnosis

• Operators have clear ways of defining cellular network performance
  ▪ Key-performance indicators

• They expect similar measures from the Femto
  ▪ Problem: often, no equivalents in the femto context

• Alternately, extensive femto/macro integration required for getting an accurate picture.
  ▪ Is it a call drop, or has the user just handed out?

• Femto vendors have to implement FSM-based diagnostic toolkit
  ▪ Should diagnose problem and suggest solutions
Sample Femto provisioning & activation

1. Factory Femtocell Provisioning
   - Serial Number
   - Shared Secrets
   - Activation URL

2. Registration
   - Link femto to billing a/c
   - Authorized User List (AUL)

3. Activation
   - Authentication (by FSM, UAG)
   - Configuration (by ANP)
Summary of challenges/opportunities

• Developing a femtocell is much more than a “porting effort” from a macrocell
  ▪ Note: even a porting effort can be substantial

• Considerable additional development has to be done at the physical/mac/protocol/application layers to realize a Femtocell solution
  ▪ Significant potential for differentiation and value-add

• There are many technical/financial challenges that are unique to femtos
  ▪ Many solutions taken for granted in macro space are unworkable for Femto
  ▪ Many problems are unsolved as of today
Thank you