Airvana

Mobile Broadband. **Everywhere.**

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

QUALCOMM®

Alcatel·Lucent

NORTEL

Deployed by over 30 global operators

Sprint Together with NEXTEL

verizon

alltel wireless

Telefónica

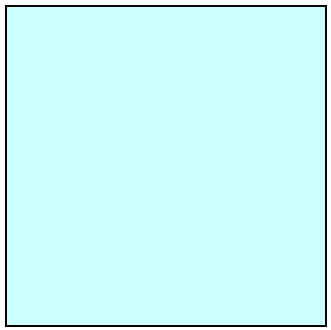
Eurotel

פלאפון

Bell

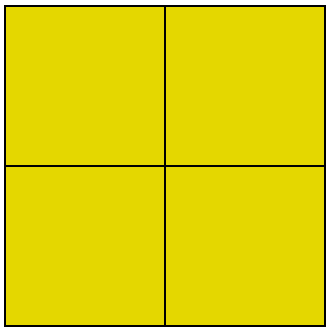
What are femtocells?

- 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



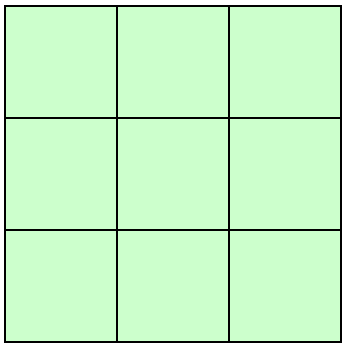
Macrocell coverage: Several km^2 .

Active users: 40



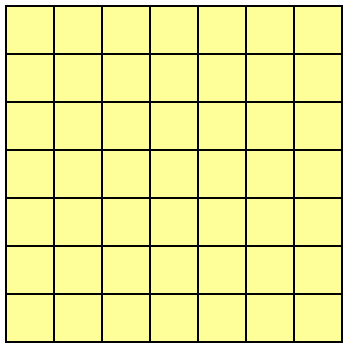
Microcell coverage: Several blocks

Active users: 40



Picocell coverage: Large hall

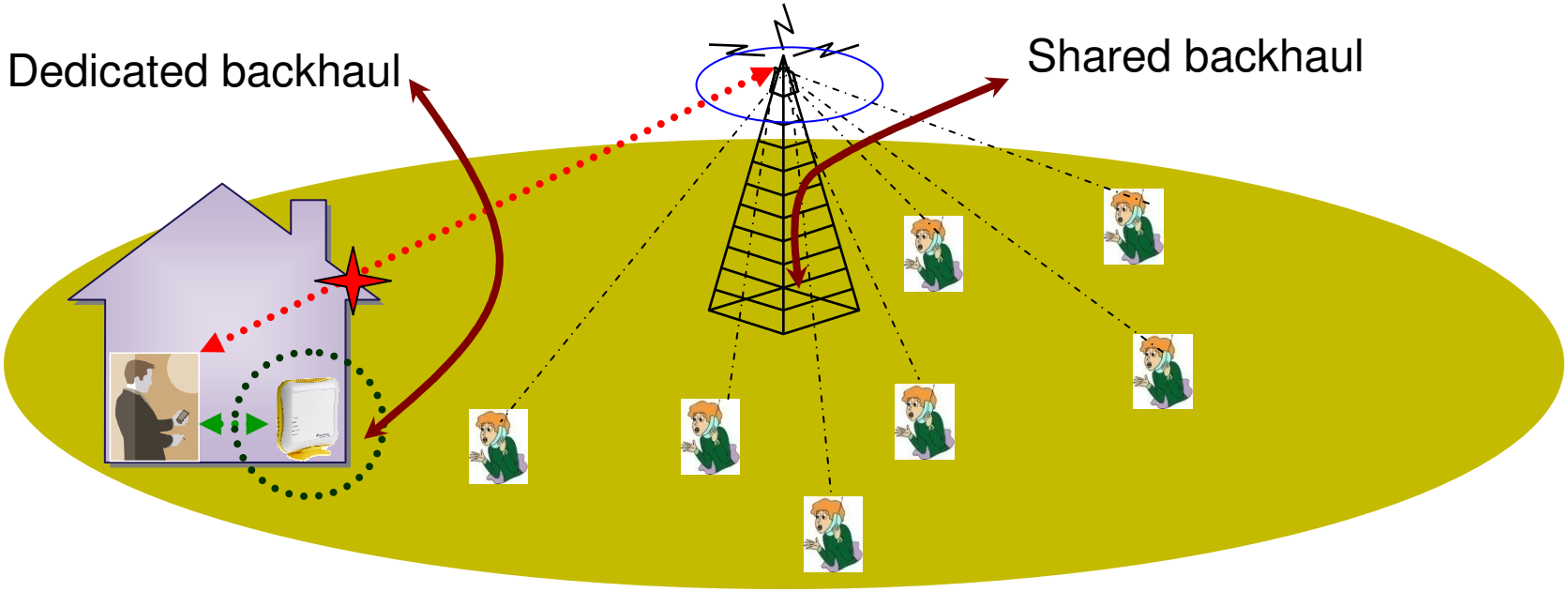
Active users: 10-20



Femtocell coverage: Large house

Active users: 4-6

Femtocells: value proposition



- Reduced Propagation Loss → Higher SINR
- Dedicated Sector Capacity for Every Femto Home
- Dedicated backhaul for every home

Femtocell: Carrier expectations summary

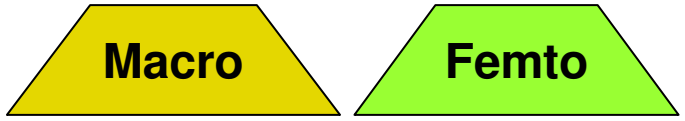
- Don't want femtocells, want an end-to-end solution
- Quality/reliability comparable to macro systems
- Easy to deploy and manage
- Cost/subscriber comparable to that in macro network

Femtocells: Technical challenges

Timing and synchronization

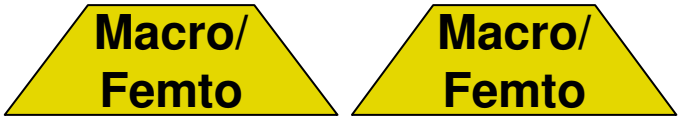
- GPS/Assisted GPS
  - When GPS signal available
- Macro `Sniffing'
  - If Macro signals detectable @ Femto
- Free running

Deployment: Shared spectrum/dedicated spectrum?



Dedicated Spectrum

- Where unused spectrum is available
- Suburban and rural areas

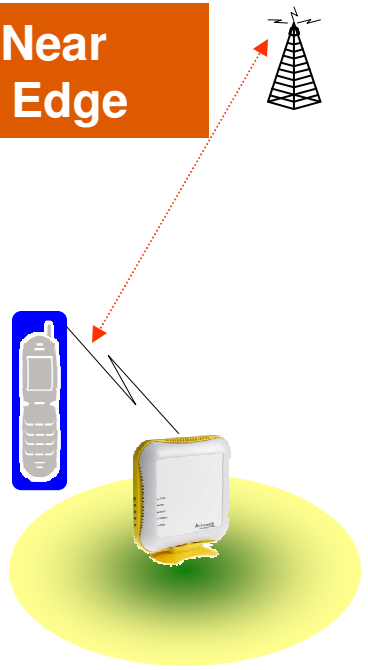


Shared Spectrum

- Where unused spectrum is not available
- Urban areas

Shared spectrum: interference challenges

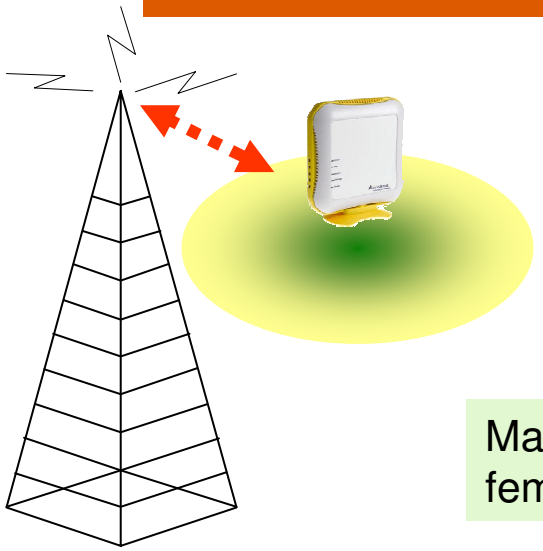
Femtocell Near Macro Cell Edge



Femto degrades macro on FL

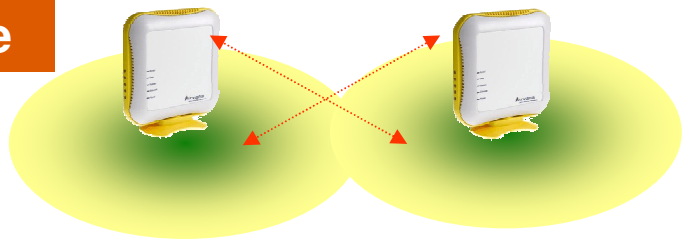
Macro user overloads femto in RL

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

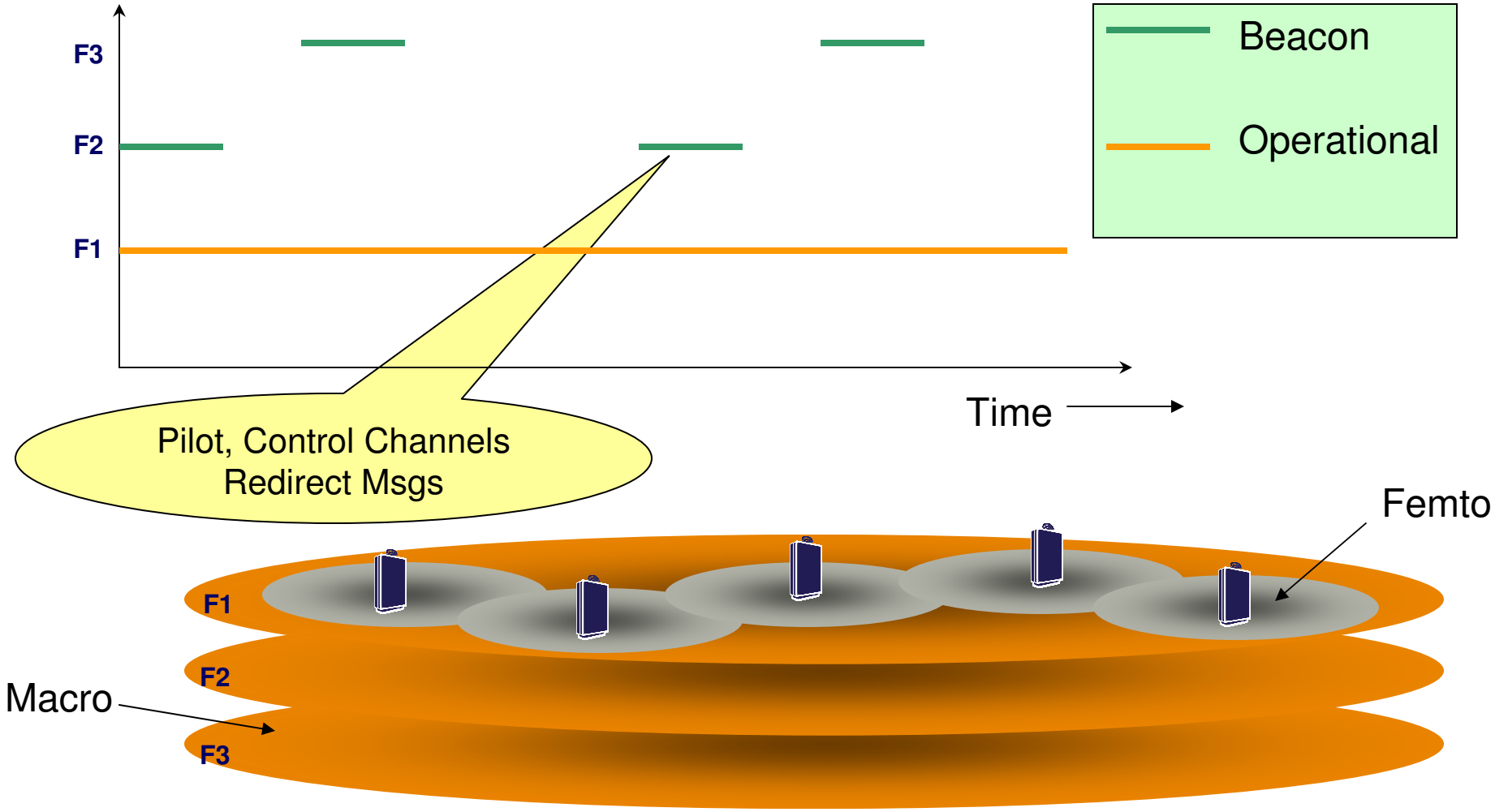
Potential solutions to interference

- 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

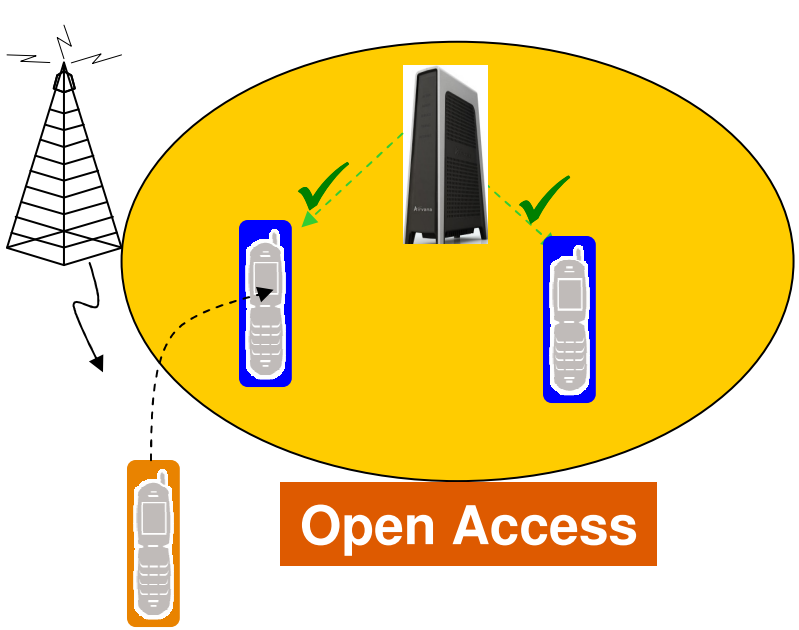
User migration between femto/macro

- 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?

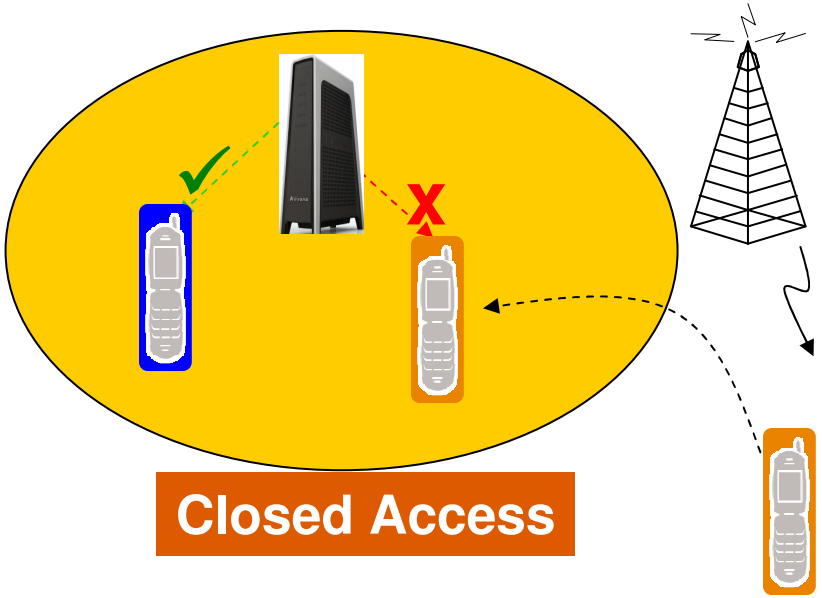


Access control



Open Access

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



Closed Access

- Only authorized users are attracted from macro frequencies
- Unauthorized users redirected to macro
- Emergency calls permitted

Femtocell network architecture

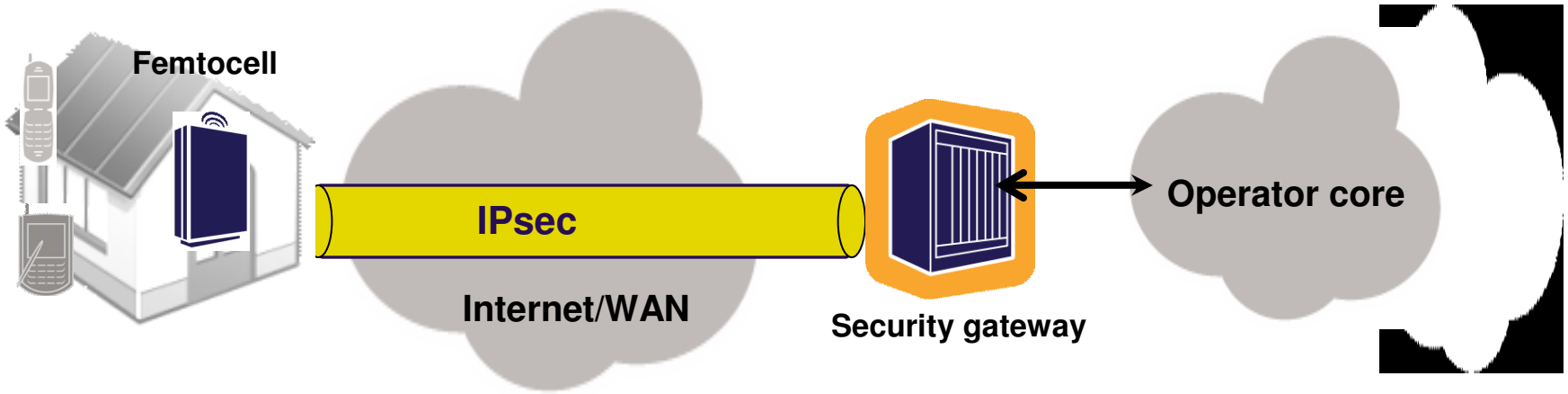
Backhaul

- 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

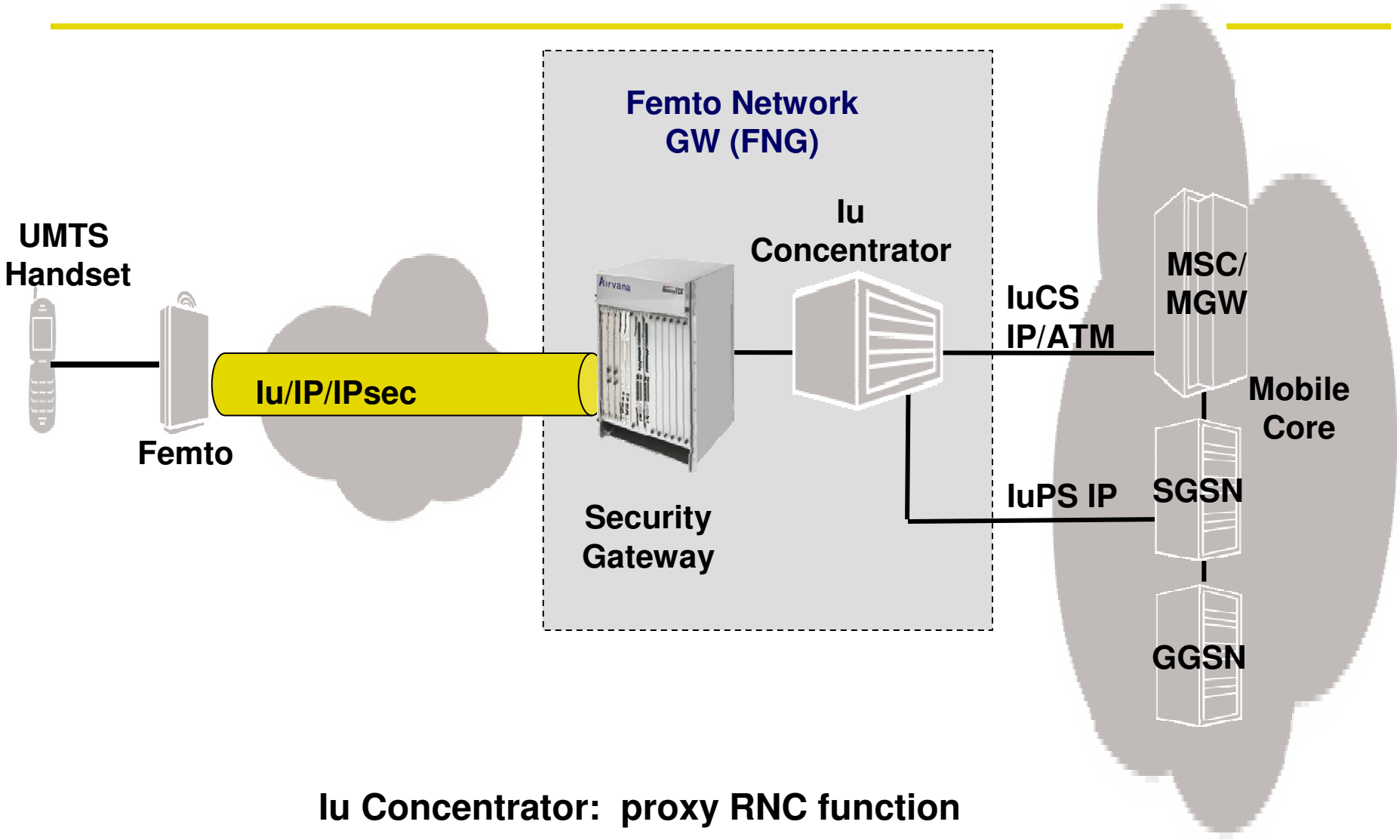
Other security considerations

- 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:

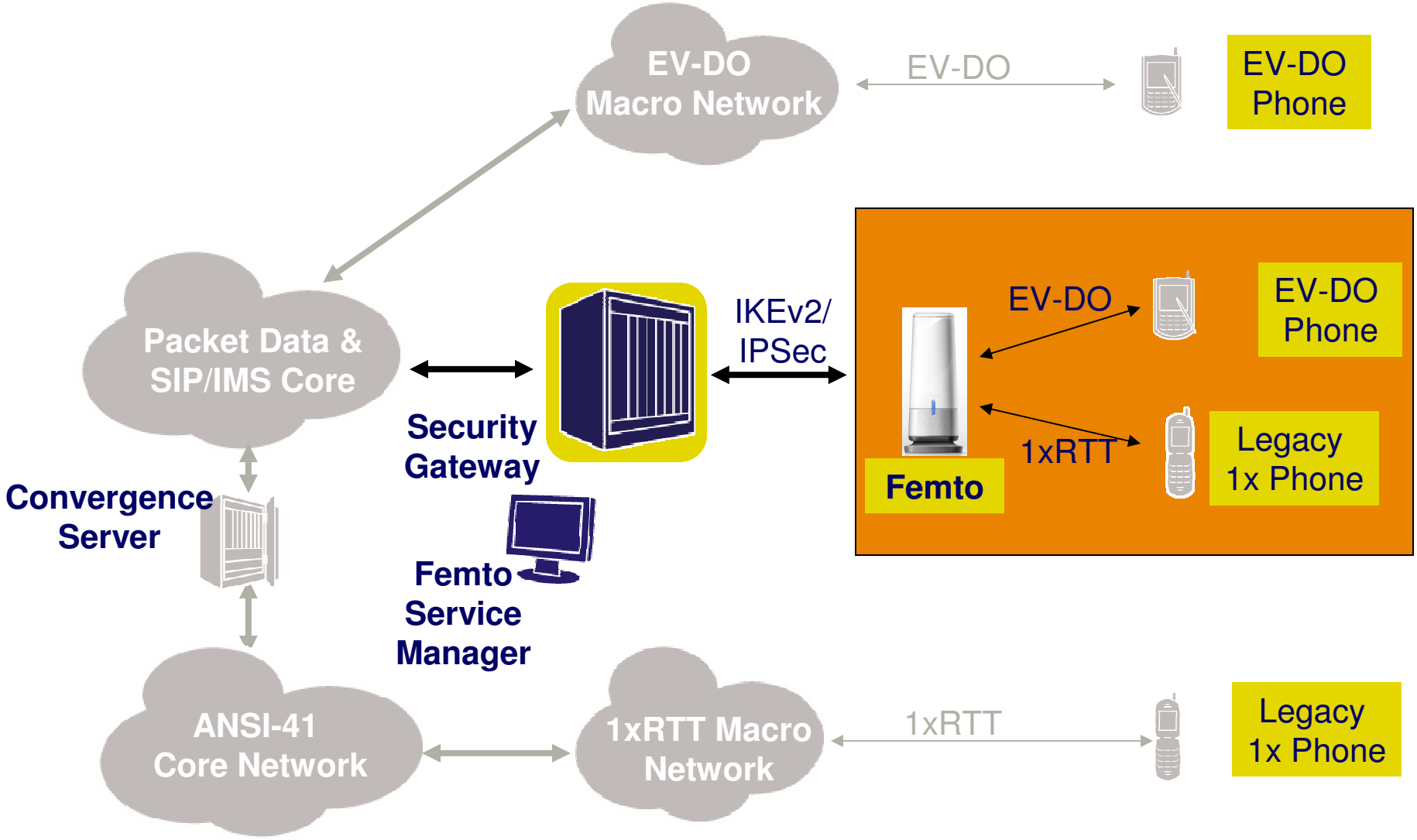
- Three distinct approaches:
  - Tunneling the RNC/MSC interface to a traditional MSC
    - » Iu over IP (GSM/UMTS),
    - » IOS over IP (CDMA)
  - SIP/IMS to the core
  - IMS/IOS hybrid

Iu tunneling (UMTS)

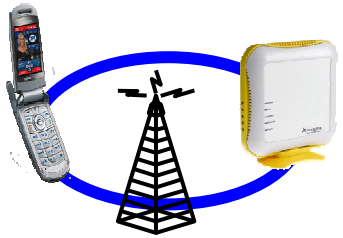


Iu Concentrator: proxy RNC function

IMS Core (CDMA example)



Future directions



"Cooperative" Hybrid Networks

New Femto-Aware Handsets
Femto-Aware Macro Network

2010+

Standardization

femtoforum
driving convergence worldwide

3G 3RD GENERATION PARTNERSHIP PROJECT 2 "3GPP2"

3GPP A GLOBAL INITIATIVE

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

"De-coupled" Hybrid Networks

Works with Existing Handsets
& Existing Macro Network

2008-2010

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

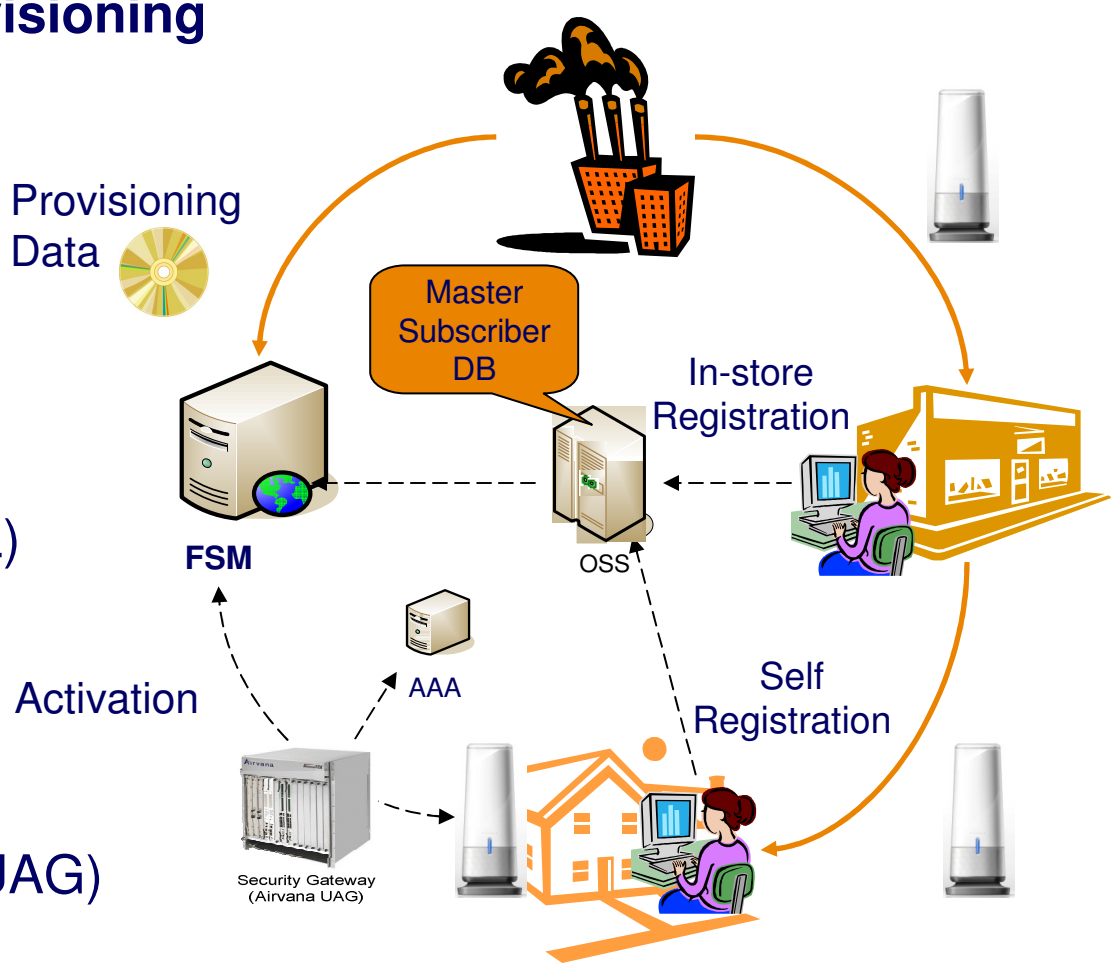
- Operators have clear ways of defining cellular network performance
  - Key-performance indicators
- They expect similar measures from the Femto
  - Problem: often, no equivalents in the femto context
- Alternately, extensive femto/macro integration required for getting an accurate picture.
  - Is it 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