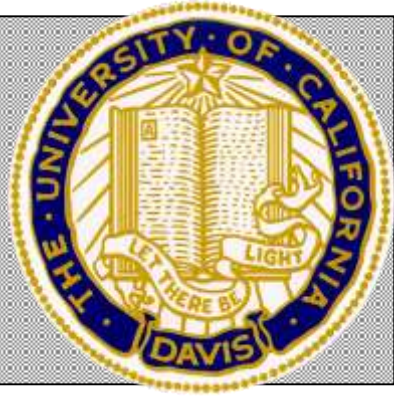


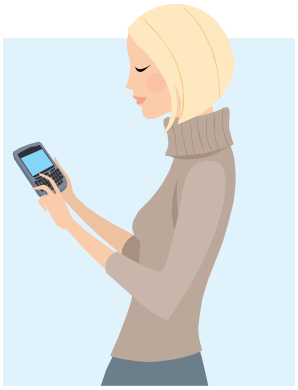
FEMTOCELL

Eiman Alotaibi

IEEE Communications Magazine
Femtocells series (Sept. 2009, and Jan. 2010)

2/12/2010

Introduction



Can You Hear Me Now!

Why?

Macrocell/Cellular System

- **Indoor challenges:**

  - High frequency
  - Wall/building penetration
  - Signal loss and attenuation

- **Other challenges:**

  - Number of end users (sharing BS capacity)
  - Infrastructure cost (OPEX and CAPEX)

Introduction

- Based on a study [1], indoor (home/office)

  - 36% voice calls (> 2/3)
  - 45% data traffic (≈ 1/2)

Femtocells

- Are small BSs operating in the licensed cellular bands
- Transmit at low power
- Placed in individual homes and backhauled onto the operator's network via DSL or cable broadband access (or fiber when available)
- Installed indoors (house/office) by end users to provide exclusive or preferential access to a designated group of users as configured by the femtocell subscriber and/or access provider

Femtocell Features

- “5 bar” coverage
- Small and low cost
  - reduces the cost of mobile calls “eventually”
- New class of services “femto-zone services”
  - music/photo/vedio service
  - high-bandwidth applications (mobile TV)
- Good indoor signaling quality and outdoor capacity
- Low number of simultaneous users per cell

Femtocell Features

- Low-power BSs

  - comparable to WiFi APs

- Licensed spectrum

- Easy configuration

  - plug-and-play
  - user installed
  - self configured
  - remotely activated and managed

Femtocell Challenges

- Interference
  - macro-femto interference
  - femto-femto interference
- Installation cost (need professional)
- Because licensed:
  - apply regulations (devices)
  - license fee
  - optimize best coverage
  - femtocell AP location

Femtocell Challenges

- Privacy and security (third party backhaul)
- Network management and arch.
- Network integration (standards)
- Qos (sharing DSL with other services)
- No DSL, routers means no femtocell!
- Hand-over/hand-out/hand-in (ff/fm/mf)
- Scalability and density
- Synchronization and location

Femtocell is not new [2]

- The concept of a compact self-optimizing home cell-site has been documented since **1999**
- Alcatel **March 1999** GSM home BS compatible with standard GSM phones (failed to implement due high cost equipment)
- Motorola **2002** claimed to have built the first complete 3G home BS
- Ubiquisys and 3Way networks (now part of Airvana) **2004** developed their own 3G cellular home BS

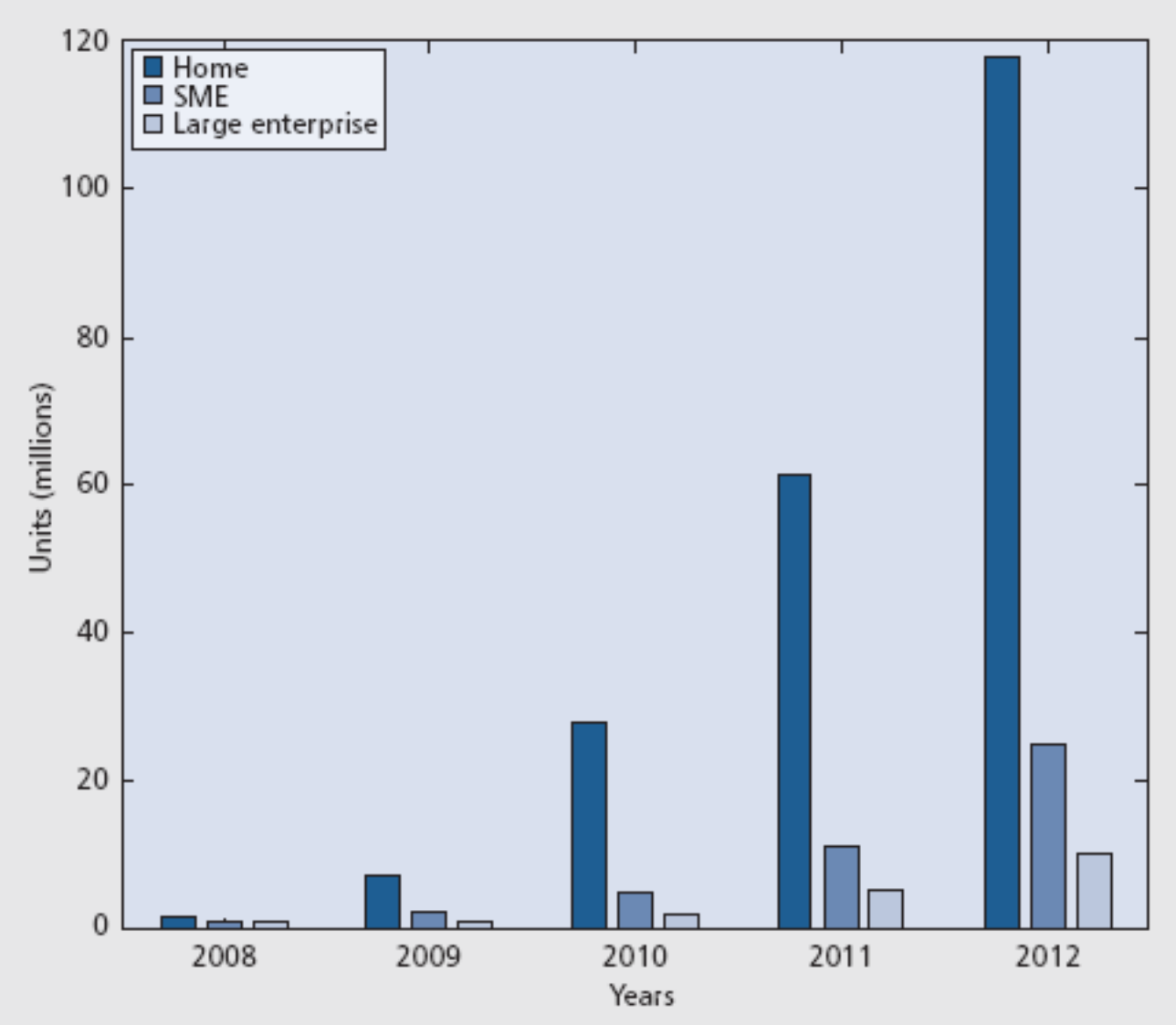
Cont.

- Femtocell **2005** the term was first documented and adopted for a standalone, self-configuring home BS
- Femto forum trade organization **2007**
- Sprint Nextel corporation **August 2008** launched commercial service
- Starhub **November 2008**, rolled out its first nation-wide commercial 3G Femtocell services
- Softbank Japan and Verizon **January 2009** announced the planned launch of their 3G femtocell

Cont.

- Vodafone **July 2009** released the first Femtocell network
- China Unicom and NTT DoCoMo (Japan) **November 2009** announced their own Femtocell network
- A number of operators have had field trials in 2008 and 2009, including Telefonica/O2, Softbank, TeliaSonera, and Vodafone
- 12 million units worldwide expected by **2014** [3]

Expectations [5]



Femto Forum

- www.femtoforum.org
- A non-standard organization established in July 2007
- The membership represents ***mobile operators***, ***equipment***, and ***component vendors***
- Main goal: “promote the femto technology by removing barriers for the introduction and adaptation of the product and services”
- Femto Forum addresses issues common to the industry
- It has proven to be an effective place to discuss key issues

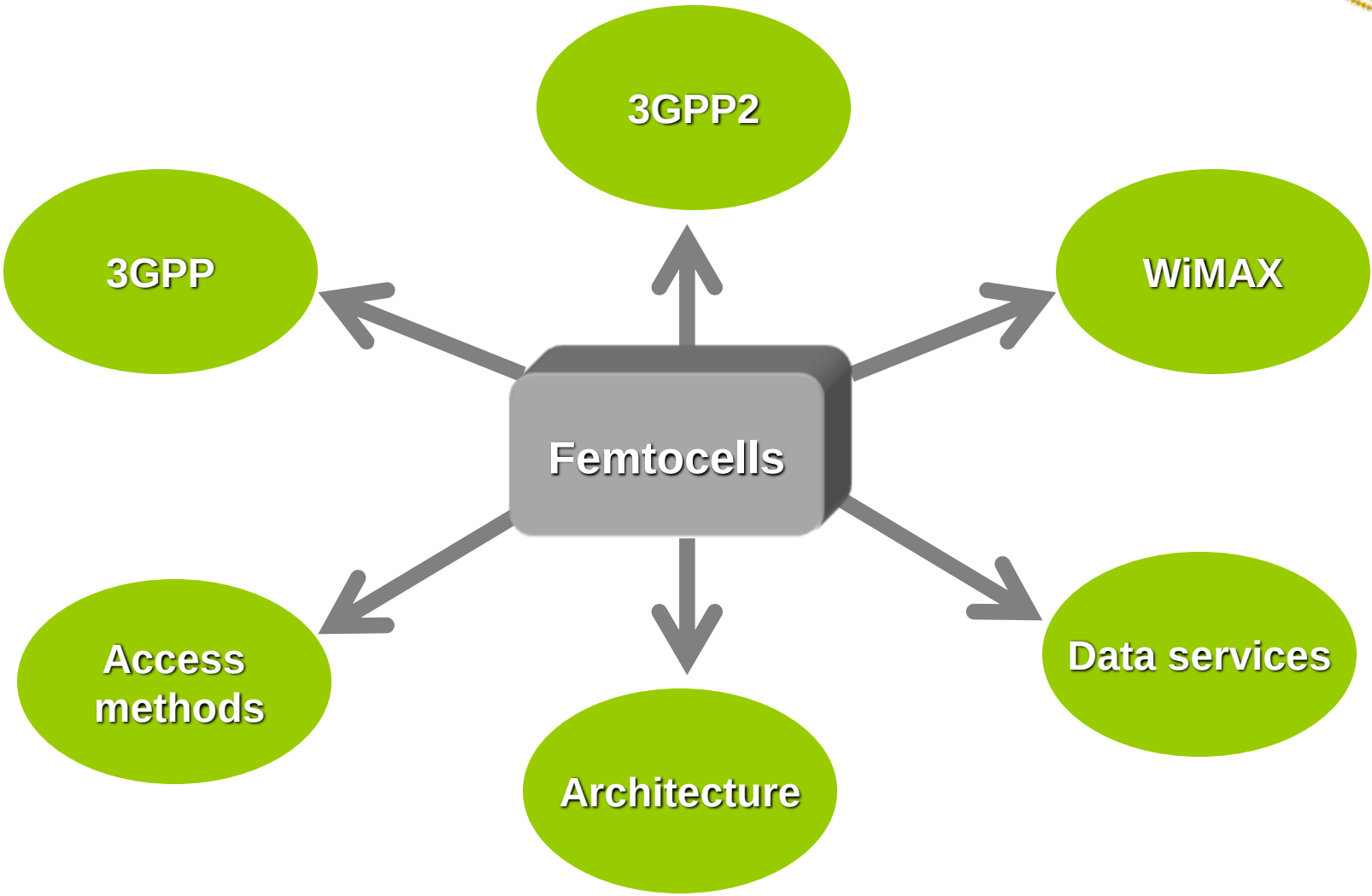
Femto Forum


AirWalk communications,inc.
Airvana
2WIRE
acme packet
ARGELA
it's the passion
ARICENT
Alcatel·Lucent
ALPHA
ASKEY
AudioCodes
bharti
Airtel
Express Yourself
at&t
BT
Cellcom
Cellcom
Clearly The Best
Carphone Warehouse
your phone, your way
Cable&Wireless
Contela
Contela, Inc.
中国移动通信
CHINA MOBILE
中華電信股份有限公司
Chunghwa Telecom Co., Ltd.
中国电信
CHINA TELECOM
CISCO
comcast
HUAWEI
mobilkom austria
ERICSSON
TAKING YOU FORWARD
hsl
Mobile Networks
ETRI
Electronics and Telecommunications Research Institute
D-Link
Building Networks for People
uygues
Telecom
GCI
We Are All Connected
INTELLINET
TECHNOLOGIES
Accelerating Convergence
Continuous Computing
Create | Deploy | Converge
BitWave
SEMICONDUCTOR
T
Intelibs
ip access
工業技術研究院
Industrial Technology Research Institute
Juni
Lime microsystems
mcom
MIMON
m1
1 life. live it.
NEC
Empowered by Innovation
NETGEAR
Connect with Innovation
node
Nokia Siemens Networks
NORTEL
LG-NORTEL
GENBAND
RELIANCE
Communications
Anil Dhirubhai Ambani Group
NTT
docomo
ROGERS

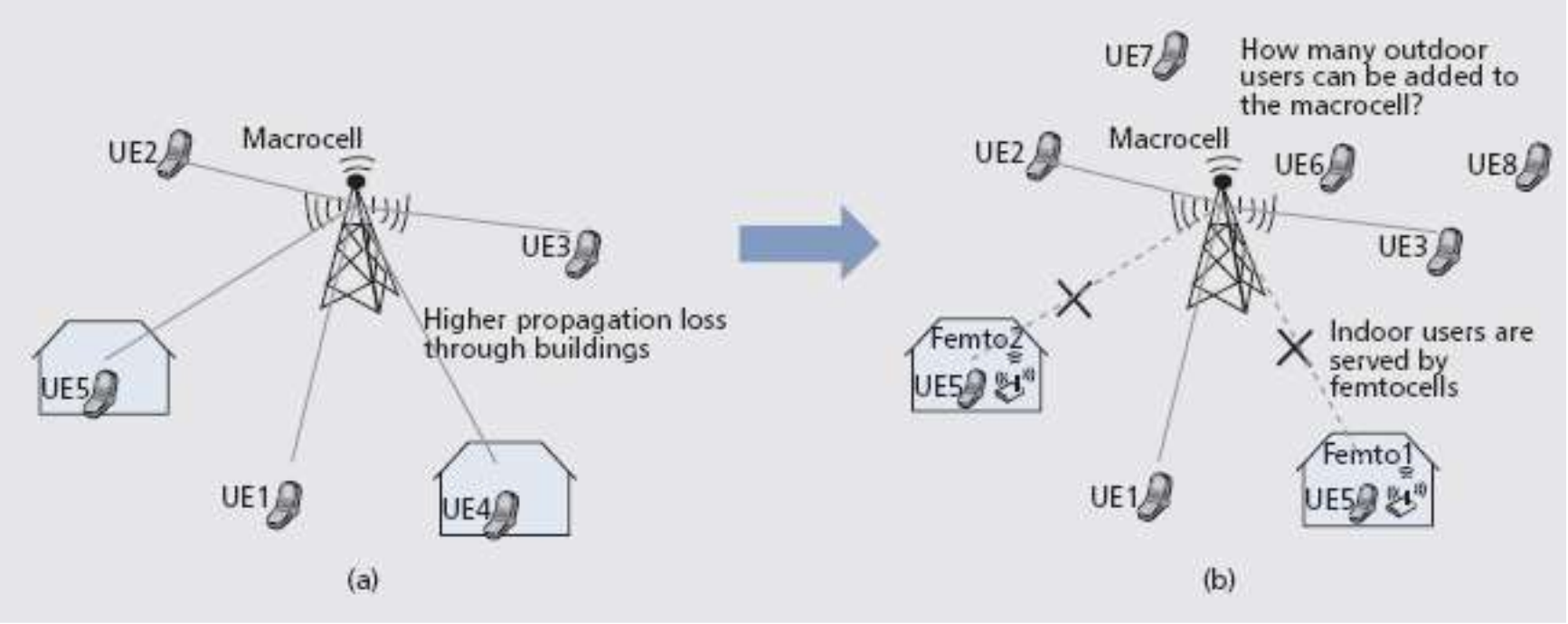
Femto Forum


truemove
SingTel
P3 communications
octasic semiconductor
SFR
O2
orange
TRAC testing regulatory and compliance
Ubiquisys
TELUS
ORASCOM TELECOM
Panasonic ideas for life
STARENT NETWORKS
PCCW
Powerwave technologies
unwired
SoftBank
Percello
Taiwan Mobile 台湾大哥大
QUALCOMM
picoChip flexible wireless
WIPRO Applying Thought
vodafone
Texas Instruments
SUMITOMO ELECTRIC
Pioneer
TOSHIBA Leading Innovation
Sprint
大同電信 TATUNG InfoComm
PIRELLI BROADBAND SOLUTIONS
Tatara Systems
Wintegra
TMC
THOMSON images & beyond
TECOM Converging Your Networks
TELECOM ITALIA
SERCOMM
SafeNet
L&T Infotech
Kineto WIRELESS
RAKON
Sagemcom
SigNav
ROSUM
SAMSUNG
SaskTel ahead by a century

Topics

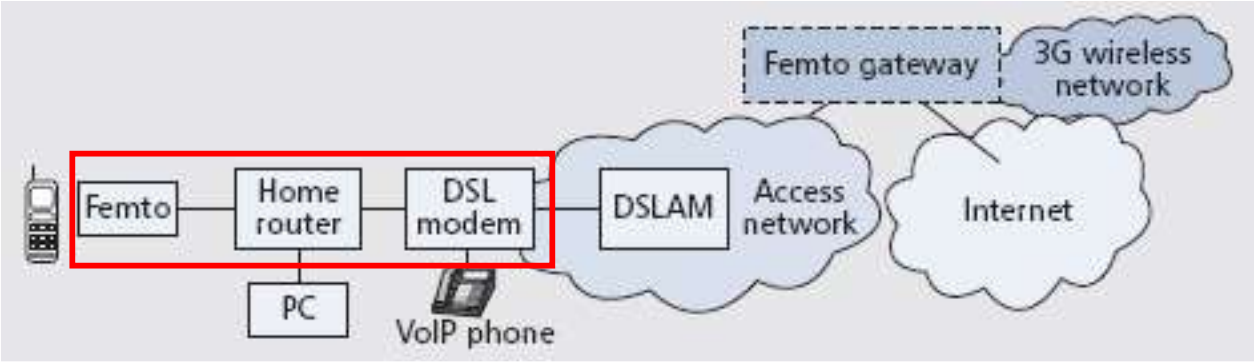

3GPP2
3GPP
WiMAX
Femtocells
Access methods
Architecture
Data services

Architecture [4]



Architecture [4]

- Standalone
- Integrated



- **<u>Potential relationship models:</u>**

1. **Common wireless and wireline operators** (static BW allocation for femtocell traffic to the gateway)
2. **Separate wireless and wireline operators with SLA** (static or dynamic BW allocation for femtocell traffic to the gateway)
3. **Separate wireless and wireline operators without SLA** (best effort BW allocation for femtocell traffic to the gateway)

Femtocell or Macrocell [4]

- At what point FAP can replace BS!

WIMAX macro offloading benefits	Reference scenario	Other scenarios (100% outdoor users, all served by the macro network)					
		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
	10 users per sector (50% indoor, 50% outdoor)	10 users per sector	11 users per sector	12 users per sector	13 users per sector	14 users per sector	15 users per sector
Cell edge user throughput (kb/s)	184.32	284.21	258.32	227.44	210.13	189.20	172.78

- scenario 5 achieves almost the same throughput as the reference scenario (40% capacity gain with no extra equipment)

Access Methods

- Closed access
- Open access
- Hybrid access

Close Access

- Only a subset of users (femtocell owner) can connect to the femtocell
- Closed subscriber group (CSG) by 3GPP
- Non-CSG are not allowed to connect through femtocell even if FAP signal is stronger than the closest BS

[5]

Close Access

- Femtocells could interfere the downlink communication of passing nonsubscribers connected to a far macrocell

- Non-CSG located close to a femtocell could interfere the femtocell uplink

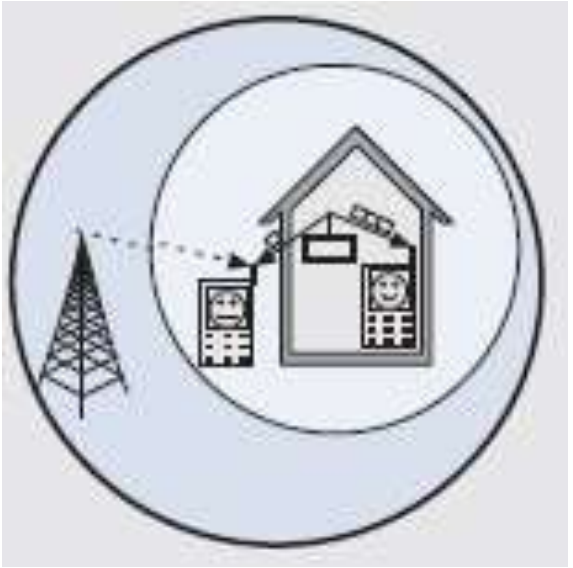
- Femtocell owner should authorize guest non-CSGs in a fast manner so that they gain access to the femtocell (emergency calls)

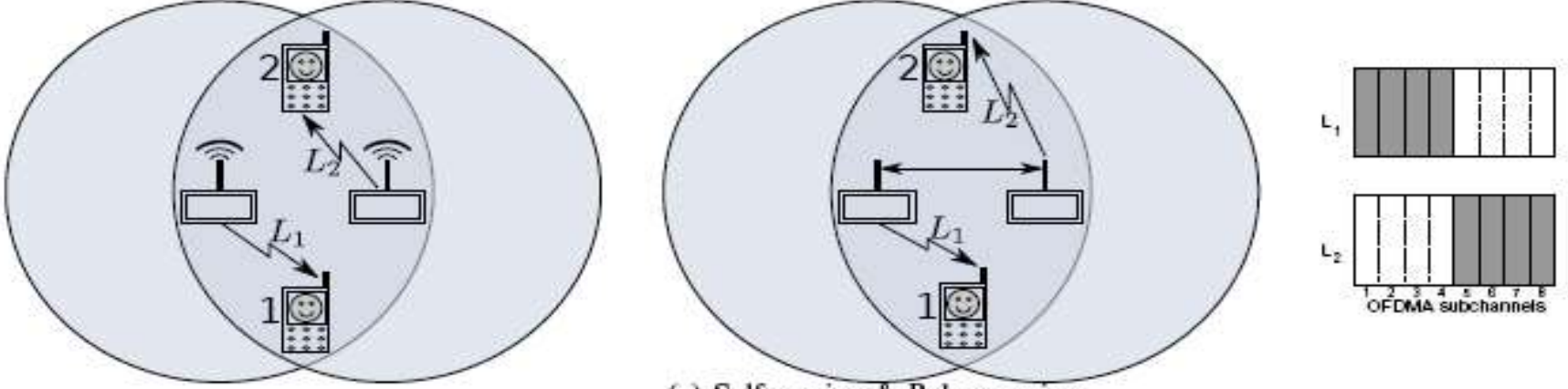
Open Access

- All customers of the operator have the right to use any femtocell
- Open FAP are placed in random locations (min interference)
- High throughput for all users
- Users always connected to stronger server
- Performance of femtocell owner reduced
- Amount of handover increased
- But who should cover the cost of femtocells and their maintenance!

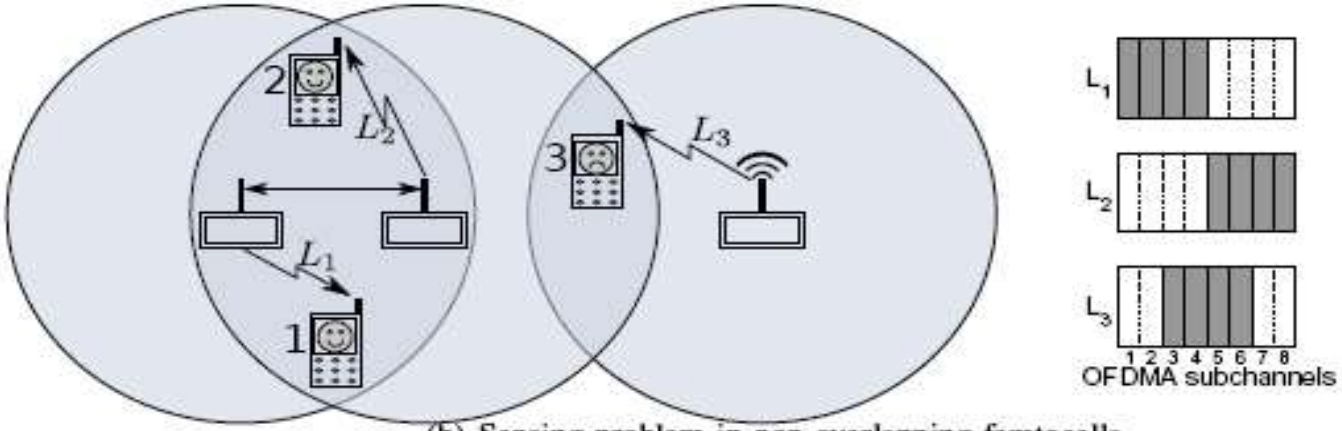
Hybrid Access

- A limited amount of femtocell resources are available to all users
- Special services are operated in a CSG manner
- To solve the interference issues, use CDMA or OFDMA technologies

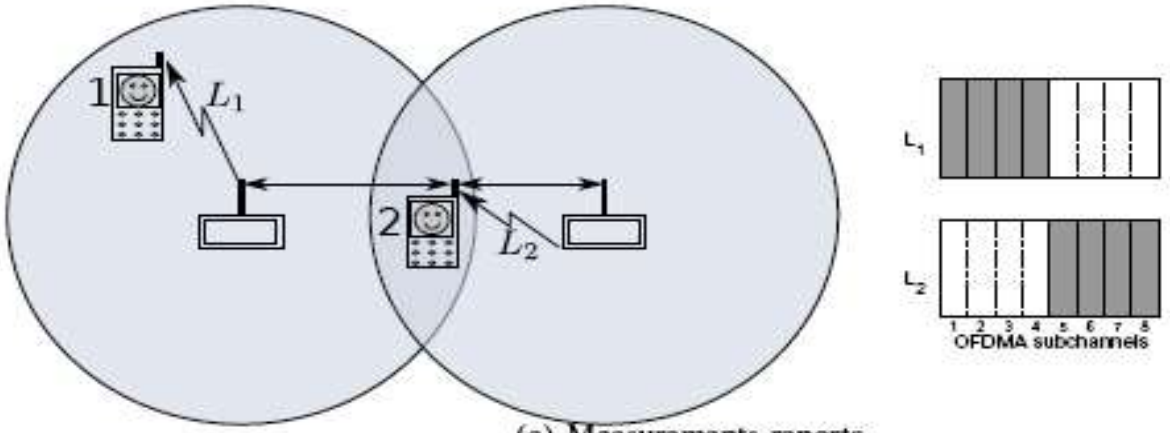




(a) Self-sensing & Relay-sensing.



(b) Sensing problem in non-overlapping femtocells.

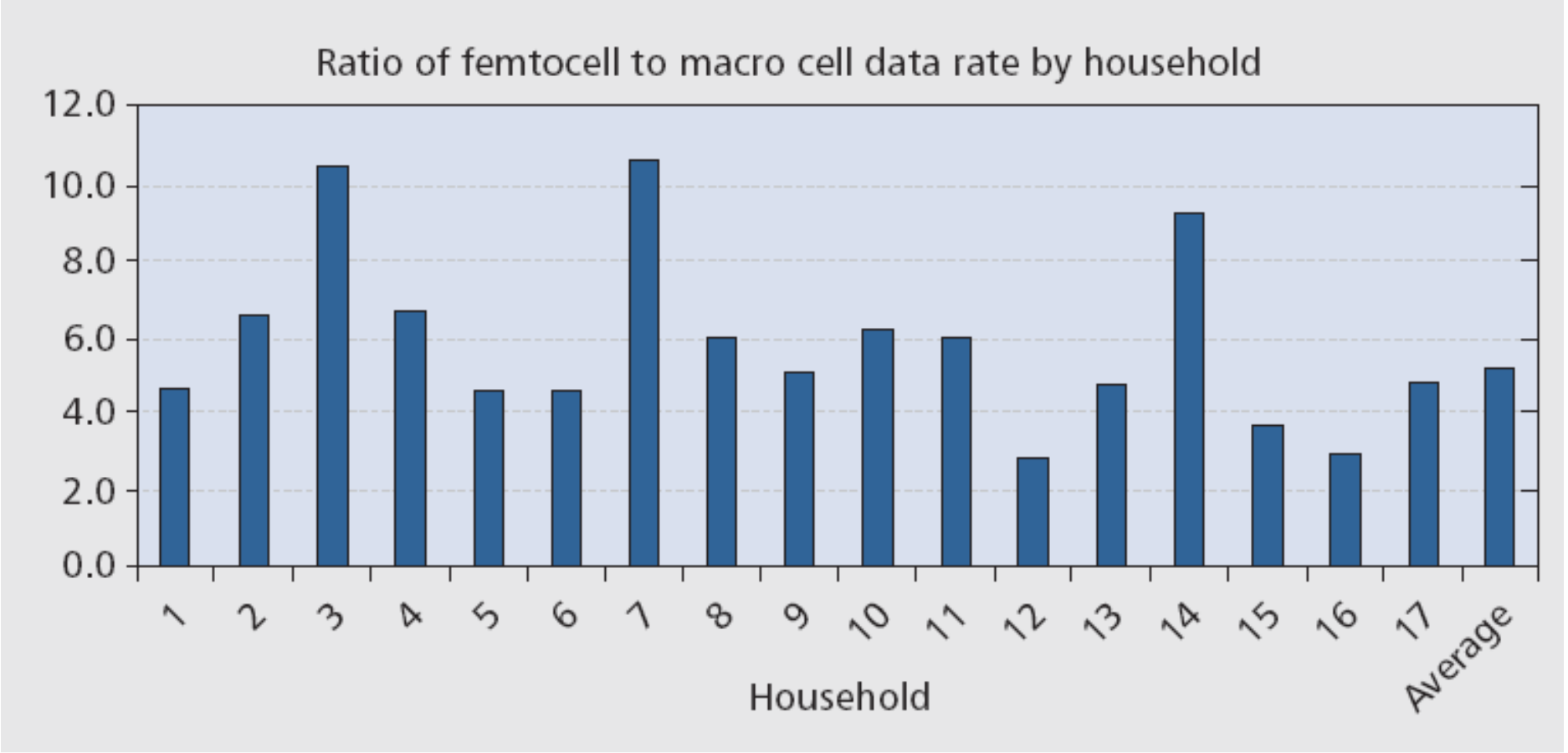


(c) Measurements reports

Data Services [6]

- Femtocells not only for voice service, they will enhance the quality of data services
- Capacity of (≈10 kb/s) can support a single voice call, broadband data services require much higher capacity
- Higher data rates require higher signal levels and signal-to-noise ratios
- Since Macrocell is a shared system with large number of users, the capacity per user is reduced
- Femtocell users will experience more improvement in delivery of broadband data services than they would for voice services

Data Services [6]



Standard: WiMAX [7]

- WiMAX Forum and IEEE 802.16 are pursuing femtocell standardization

- Phase 1:

  - requires no air interface or MS change
  - network support
  - expected to be available (2010–2011)
  - considering near-term challenges of interference mitigation and self organization and integration of retail distributed femtocells
  - expected that initially femtocells will operate in different frequency channels than macrocells and be provisioned and distributed directly by operators

- Phase 2:

  - more advanced and optimized femtocell features (IEEE 802.16m, WiMAX Release 2.0) (2012–2013)

Standard: 3GPP [8]

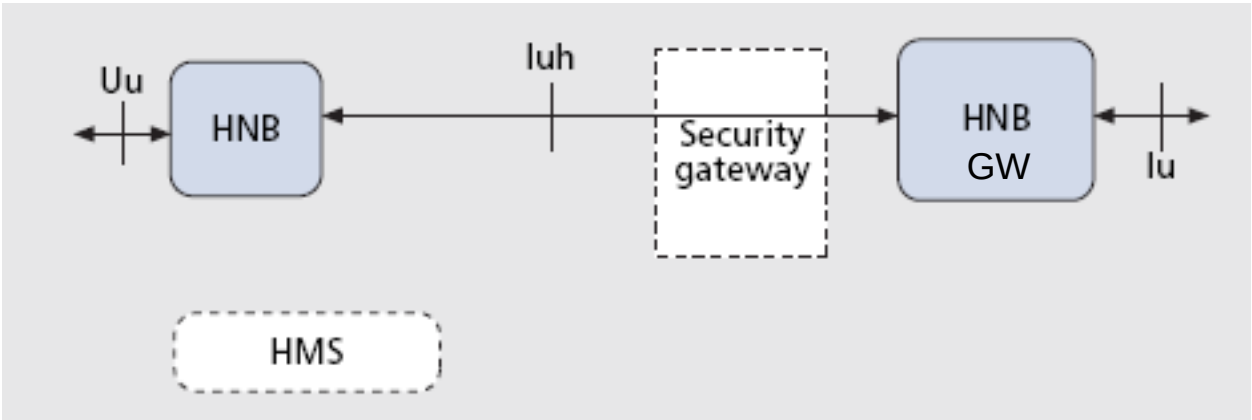
3 G Partnership Project

3GPP terminology	Generic terminology	Definition
HNB (home NodeB)	Femtocell	The consumer premises equipment (CPE) device that functions as the small-scale nodeB by interfacing to the handset over the standard air interface (Uu) and connecting to the mobile network over the Iuh interface.
HNB-GW (home NodeB gateway)	FAP-GW (FAP Gateway)	The network element that directly terminates the Iuh interface with the HNB and the existing IuCS and IuPS interface with the CN. It effectively aggregates a large number of HNBs (i.e., Iuh interface) and presents it as a single IuCS/PS interface to the CN.
HMS (home NodeB management system)	ACS (Auto-Configuration Server)	The network element that terminates TR-069 with the HNB to handle the remote management of a large number of HNBs.

Standard: 3GPP

- HNB-GW acts as a concentrator to aggregate a large number of HNBs
- From the CN's perspective, it appears as if it is connected to a single large radio network controller (RNC)
- Femtocell system architecture does not require any changes to existing core network systems
- Existing standard is reused unchanged (except for some minor modifications to accommodate HNB specific needs)

  - UE is the existing Uu interface with minor modification to include CSG related information



Standard: 3GPP2 [9]

- 3GPP2 (3G Partnership Project 2) found in1999
- http://www.3gpp2.org
- Initially: United States, Korea, and Japan
- Facilitate the standardization of code-division multiple access (CDMA)-based radio technologies for cellular communication
- In subsequent years, China membership was added
- partnerships with Femto Forum

Standard: 3GPP2

- 3GPP2 initiated work on femtocell standardization in early 2007

- Two key objectives distinguish the 3GPP2 femtocell architecture:

1. Evolution of voice services (including legacy circuit voice services) toward an all-IP architecture based on Session Initiation Protocol (SIP) and IP multimedia subsystem (IMS)

2. Reuse of existing 3GPP2 standardized interfaces and entities to enhance femtocell systems marketing time

Conclusion [10]

- Femtocell is a promising technology
- Recent standardization activities in 3GPP/ 3GPP2 will lead to a new generation of standardized femtocell solutions and raise the expectation for commercial market success for operators and vendors
- Initially, femtocells will be utilized for coordinated coverage extension purposes (e.g., public areas) and niche markets (high-value customers, enterprise packages), rather than mass market commercial offerings

References

[1] D. Mavrakis and M. Kamal-Saadi, Mobile Broadband Access at Home: The Business Case for Femtocells, UMA and IMS/VCC Dual Mode Solutions, Informa Telecoms and Media, Sept. 2008

[2] http://www.thinkfemtocell.com/FAQs/femtocell-history.html

[3] http://berginsight.com/News.aspx?m_m=6&s_m=1

[4] Doru Calin, Holger Claussen, and Huseyin Uzunalioglu, On Femto Deployment Architectures and Macrocell Offloading Benefits in Joint Macro-Femto Deployments, (Alcatel-Lucent)

[5] Guillaume de la Roche, Alvaro Valcarce, David López-Pérez, and Jie Zhang, Access Control Mechanisms for Femtocells

[6] Jay Weitzen and Theodore Grosch, Comparing coverage quality for femtocell and macrocell broadband data services, (Airvana)

[7] Ronny Yongho Kim, Jin Sam Kwak, and Kamran Etemad, WiMAX Femtocell: Requirements, Challenges, and Solutions, (LG, Intel)

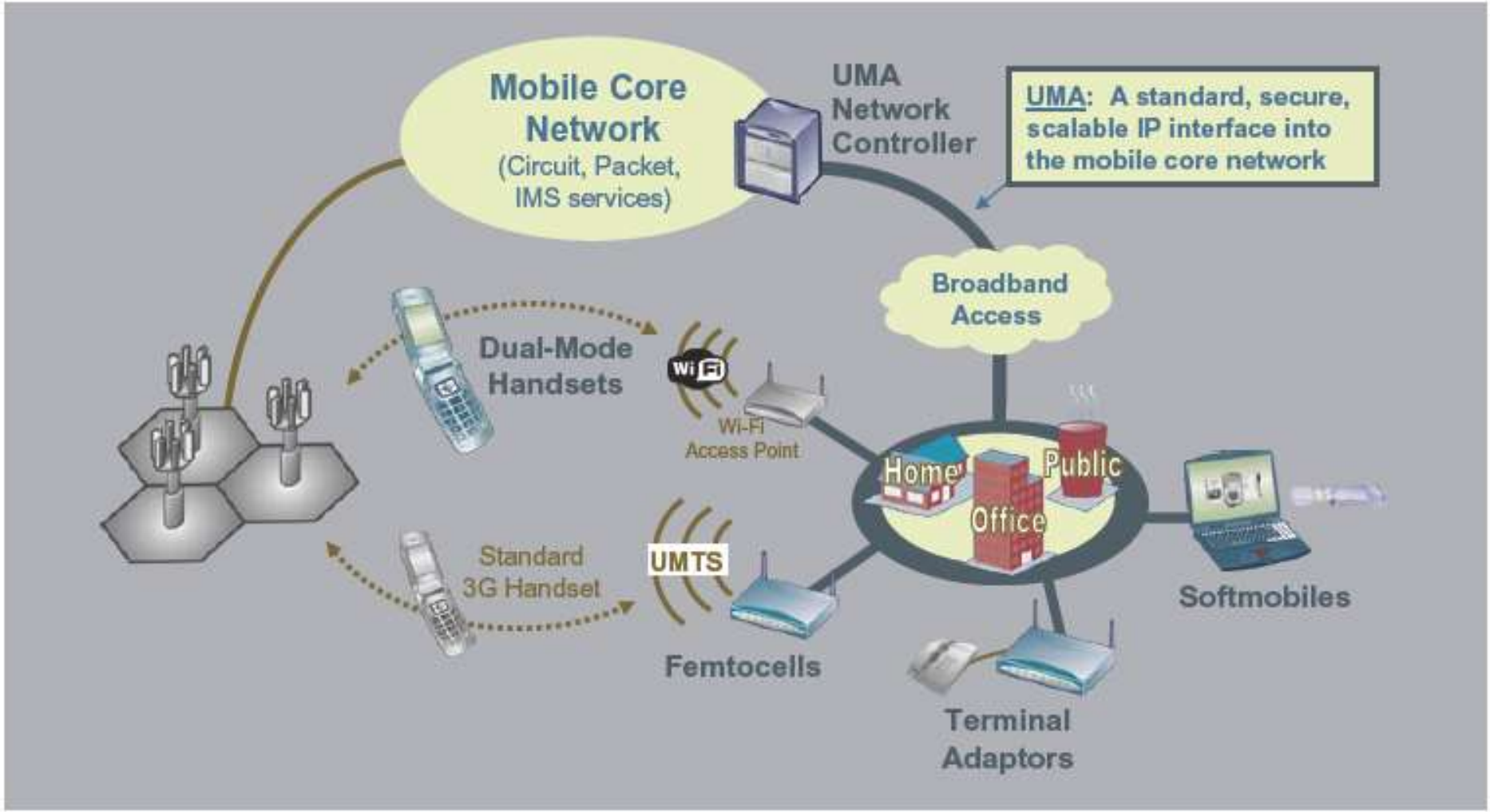
[8] Douglas N. Knisely, Takahito Yoshizawa, and Frank Favichia, Standardization of Femtocells in 3GPP, (Airvana, Thomson Telecom, Alcatel-Lucent)

[9] Douglas N. Knisely and Frank Favichia, Standardization of Femtocells in 3GPP2, (Airvana, Alcatel-Lucent)

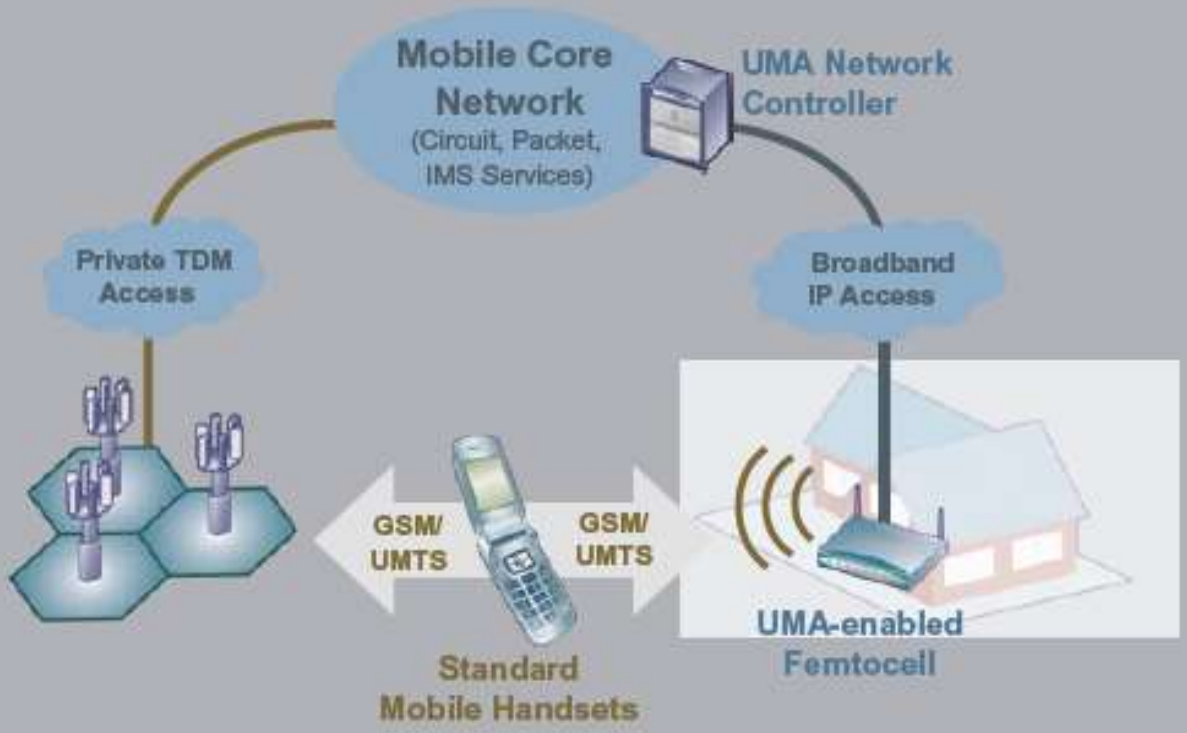
[10] George Korinthios, Elina Theodoropoulou, Niki Marouda, Ioanna Mesogiti, Eftychia Nikolitsa, and George Lyberopoulos, Early Experiences and Lessons Learnedfrom Femtocells, (COSMOTE)

UMA Today: Femtocell Opportunity Expanding

UMA moves to "Universal Mobile Access"



UMA Solves Femtocell Network Challenge



Standardized, secure IP access to mobile networks and services

Supports ad hoc service activation

Scalable architecture designed for millions of user-installed femtocells

FMC, VoWiFi
The threat for cellular operators

- Wireless market saturated - operators need new strategies to drive ARPU and gain customers
- Threats from new entrants (MVNO, Voice-over-WiFi)
- Strong desire to shift users to 3G (or other data services)
  But… 3G coverage is lousy indoors (especially for data)
- Femtocells allow Wireless operators to (profitably) compete with voice-over-WiFi