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The Case for UMA-Enabled Femtocells

Why the mobile industry is turning to UMA for a standard, cost-effective approach for integrating femtocells back into the core network.

January 2007

A Kineto White Paper

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Introduction

The wireless industry has been searching for low-cost indoor coverage solutions since the beginning of mobile networks. For practical and cost reasons, indoor coverage is normally designed into the outdoor macro network by statistically budgeting for wall attenuation when signals propagate through external walls of buildings. While the intent is to achieve a high percentage of cases with satisfactory indoor coverage, it is cost prohibitive to design RF coverage for 100% of indoor scenarios.

To date, a small sub-sector of the wireless equipment industry has satisfied the indoor coverage market by offering cost-effective picocell solutions for high-traffic and high-worth locations. Unfortunately, the bulk of the indoor coverage opportunity (i.e. residential environments) has been beyond the addressable market for cost and operational reasons.

However, recent developments in 2G and 3G silicon have once again raised the possibility of offering low-cost femtocells to address the residential indoor licensed coverage opportunity. Technology companies such as picoChip, RadioFrame Networks, ip.access, and UbiquiSys are working on femtocell products expected to meet tough budgets. This development is encouraging for the indoor coverage market and addresses some, but not all, of the challenges for successful femtocell service deployments.

For example, the need for a scalable, secure and operationally sustainable approach for integrating femtocells into a core service network remains unsolved. This paper shows how the 3GPP Unlicensed Mobile Access (UMA) standard is uniquely positioned to address this challenge.

Technical Requirements for Successful Femtocell Deployment

For mobile network operators (MNOs) to achieve mass adoption of a femtocell-based indoor coverage service, three key technology requirements must be met:

1. Low-cost femtocell products (under €150)
2. Reasonable approach for managing RF interference
3. Scalable, cost-effective approach for core network integration

Low-Cost Femtocell Products

The physical femtocell is the single largest cost item in the operator business case for deploying a femtocell-based indoor coverage service. The economics of deployment depend on vendors achieving highly cost-optimized designs. It is widely expected by mobile network operators evaluating this technology that femtocell units must cost under €150 in volume in order to develop a successful business case.

Fortunately, femtocell chipset and access point vendors are now publicly stating their ability to meet these aggressive cost targets over the next several years.

Reasonable Approach for Managing RF Interference

As a simple matter of physics, femtocells operating in the same frequencies as macro cells risk interfering with the macro network. In a normal operator-controlled RF plan, the frequency allocation (and scrambling code allocations in the case of W-CDMA) are carefully planned to avoid interference between transmitters. In the case of femtocells, the idea of prescriptive RF planning for millions of devices is simply unimaginable. Fortunately, vendors in the femtocell space are now claiming to have invented techniques to address the RF interference issues. Femtocell-macro cellular interference is a very active area of research, and a number of recent studies have been conducted analyzing the potential RF interference issues with promising results. Throughout the remainder of 2007, lab experiments and real world field measurements in representative environments are scheduled to validate the efficacy of these new RF interference management techniques.

Scalable, Cost-Effective Approach for Core Network Integration

In a mobile network, Base Stations (BTSs) and Node Bs enable mobile handsets to access network infrastructure that control and deliver services from the mobile network core. In the same fashion, a femtocell must enable handsets to access those same infrastructure elements through an access network.

However, unlike operator owned and operated BTSs and Node Bs (which leverage private high-capacity dedicated links for backhauling traffic to the mobile core), the economics of a femtocell-based service dictate the use of the public Internet for connectivity and core network access.

While vendors have made significant progress in addressing cost and interference issues, less progress has been made in solving the core network integration challenge. This is primarily because conventional mobile network infrastructure is not well equipped to meet the unique challenges of femtocell-based services:

Mass Scalability

- Radio Network Controllers (RNC) are designed to handle hundreds of high-usage Node Bs, not millions of low-usage femtocell access points.
- Treating each femtocell as a Node B interfaced to the RNC is cost prohibitive. Even if many femtocells can be aggregated to appear as a single Node B, RNCs have the wrong cost structure and scalability to serve as the access interface to the mobile network.

Service Security

- Running the Iu-b interface over the Internet requires a new security layer to protect the RNC and mobile network from Internet attacks.
- There are no defined mechanisms for controlling access to a femtocell-based service. Both femtocells and handsets accessing service through those cells need to be properly authenticated and individually authorized for access.

Network Operations

- Macro network radio planning and systems are not designed to support the consumer behavior of potentially millions of unplanned femtocell moves/adds/changes.

Standardized Interface

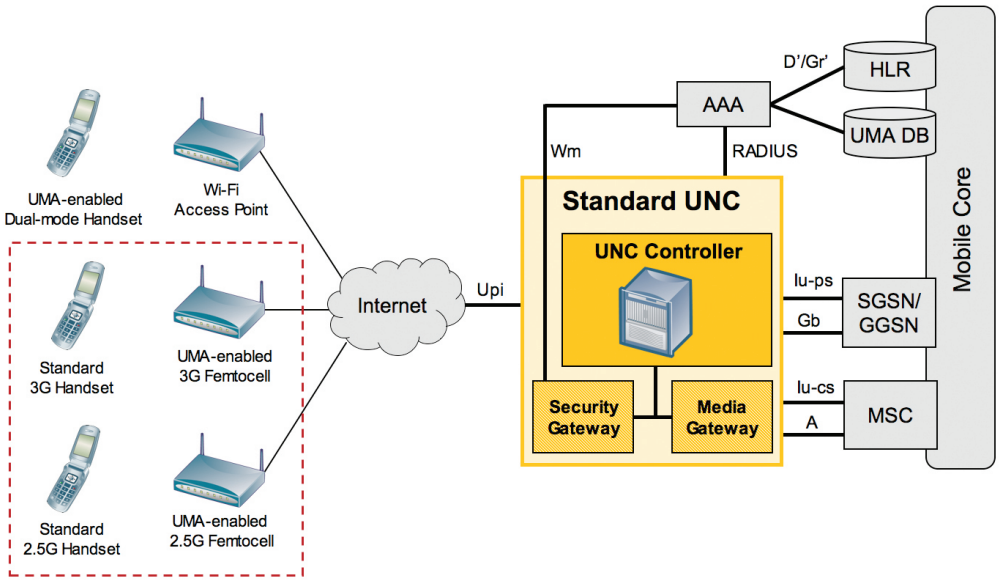
- The Iu-b interface is not 100% interoperable between different Node B and RNC vendors. A true mass market can only develop with a fully standardized and interoperable interface between femtocells and the mobile core network.

While it is clear that existing RAN access infrastructure is ill-suited for femtocell deployments, the 3GPP UMA standard, originally defined to enable millions of dual-mode cellular/Wi-Fi mobile handsets to access mobile services over the Internet, can be directly leveraged to address this access network challenge. UMA provides a standard, scalable and cost-effective IP-based access infrastructure that can be leveraged by femtocells in the same manner as it is currently by used by dual-mode handsets and Wi-Fi access points.

Leveraging UMA for Femtocell Integration into Core Networks

Originally developed to support dual-mode cellular/Wi-Fi mobile handset services, the 3GPP UMA standard provides a standard, scalable and cost-effective method for end-user devices to access mobile network services over any IP-based access network, including the Internet.

As is often the case with a new standard technology, innovative companies learn to apply it in new and innovative ways. Recently, it has been demonstrated that UMA can be directly leveraged to address the core network integration challenge of femtocell-based service by providing a standard, scalable, IP-based interface into mobile core networks. The diagram below shows a functional diagram of UMA supporting 2G and 3G femtocell access points.



NOTE: The Up interface defined in the 3GPP UMA standard is currently being extended to support end-user devices wishing to communicate to mobile core network in 3G-mode (Iu core interface) in addition to 2.5G-mode (A/Gb interfaces). The updated 'Up' interface is labeled as 'Upi' in the diagram above.

Femtocell Operation

To leverage UMA for access to the mobile network core, the UMA client functions reside in the femtocell rather than the mobile handset, as is the case with UMA-based dual-mode cellular/Wi-Fi services. As a result, any standard, off-the-shelf UMTS/GSM handset can attach to the femtocell air interface module, with the femtocell performing the interworking function between the UMTS/GSM air interface and the Upi interface to the UMA Network Controller (UNC) in the core network.

The minimum functional elements are a 2G or 3G air interface module, UMA client module, standard UMTS/GSM SIM, and IP networking interface. Upon power up, the UMA-based femtocell uses a standard SIM/U-SIM to authenticate to the mobile network and to create a secure IPsec tunnel between the femtocell and the UNC security gateway. The femtocell then uses existing standard UMA procedures to discover and register with the appropriate UNC, so that handsets attached to the femtocell are always connected to the correct serving MSC & SGSN. This important and automated step minimizes the femtocell-macro cell planning and ensures seamless handover between the two access points. If the UNC accepts the femtocell UMA registration, the UNC provides the system information needed to go into service over the air interface.

Handset Operation

Handsets, upon arriving in the vicinity of a UMA-based femtocell, detect its presence through normal GSM and UMTS radio procedures. When the handset attaches it triggers a UMA registration by the femtocell on behalf of the handset. The femtocell must successfully register the handset with the UNC, and the handset must be authenticated by the mobile core network to be authorized for service access.

This is a standard feature of the UMA registration procedure for each visiting handset, and allows the UNC to provide network-based service access control per subscriber and device. This also means MNOs can control access policies from the network without depending on femtocell-based access controls to be trustworthy.

UNC Operation

The UNC terminates the Upi interface from the femtocell. The security tunnel layer is typically terminated by a UMA Security Gateway. The UNC application layer handles the UMA service control and media forwarding functions. Almost all operations over the Upi interface are common between dual-mode handset services and femtocell AP services.

Since both dual-mode UMA handsets and femtocells use the same Upi interface, the UNC will be able to support both types of access concurrently. For MNOs, this means a single UMA UNC investment supports both dual-mode handsets and femtocell AP access applications.

Service Operation

Leveraging UMA for femtocell integration into the network also means an MNO's existing core network is utilized for service control and delivery. Economically, this means femtocells can connect to an existing network with no new core network investment (except capacity) – an operationally and financially friendly solution.

For subscribers, this means seamless access to the same network services they receive when connected to the macro cellular network, from voice, voice VPNs, VMS, SMS, MMS, GPRS, WAP, Blackberry, content services, PoC, IMS, and even future unforeseen future services.

For MNOs, this means one service core hosts all access networks whether they are GERAN, UTRAN, UMA for dual-mode handsets, or UMA-enabled femtocells. Planning for the future, new network services can be rolled out without any special dependencies on the femtocells.

Advantages of UMA for Femtocell Core Network Integration

By leveraging UMA for core network integration, all the benefits of UMA-enabled dual-mode handsets extend directly to UMA-enabled femtocells and standard mobile handsets, including:

Mass Scalability

- Proven approach for integrating millions of end-user devices into the core network

Advanced Service Security

- Secure, authenticated access over the Internet for femtocells into the core network
- Secure, authenticated access for handsets attached to femtocells
- Network controlled, flexible service access control for femtocells and handsets

Simplified Network Operations

- Optimized installation and activation for millions of unplanned, ad hoc femtocells
- Automatic, dynamic assignment of femtocells to the correct serving MSC using standard discovery and redirection procedures
- Static macro BSC/RNC provisioning for support of handover between femtocells and macro-cells using standard UMA concepts

Standard Interface

- UMA provides a well defined 3GPP standard interface between the femtocells and the core network, enabling a vibrant, interoperable femtocell market

Full-Service Transparency

- Transparent access to all circuit, packet and IMS-based services
- Automatic handover between macro-cells and millions of femtocells

UMA: The Standard for IP-based Access to Core Networks

This whitepaper identified three key challenges for successful femtocell deployment:

	Challenge
1.	Low-cost femtocell products (under €150)
2.	Reasonable approach for managing RF interference
3.	Scalable, cost-effective approach for core network integration

The rationale for leveraging UMA network connectivity for femtocells is unmistakable. The conventional mobile RAN architecture stands in the way of a healthy femtocell market. Even with the addition of Iu-b over IP interface concentrators, the fundamental operation of RNCs and BSCs fail to address the operational challenges of supporting millions of APs self-installed by consumers. Fortunately, the 3GPP UMA standard provides a scalable and operationally sustainable solution for adding millions of femtocells to the mobile network.

An open, standardized interface between femtocells and the MNO network is a pre-requisite for growing the femtocell market. The Upi interface provides such an interface. If MNOs standardize on the Upi interface for enabling femtocell integration with the mobile network, femtocell vendors will be able to address their products for a large, harmonized market rather than reworking them for each MNO network.

Currently, the lack of a clear core network integration strategy for femtocells is fragmenting the industry and damaging market viability. Leadership from the MNO, femtocell vendor, and UMA sectors is required to standardize the access network architecture and catalyze a volume business for femtocell solutions for the benefit of all parties.