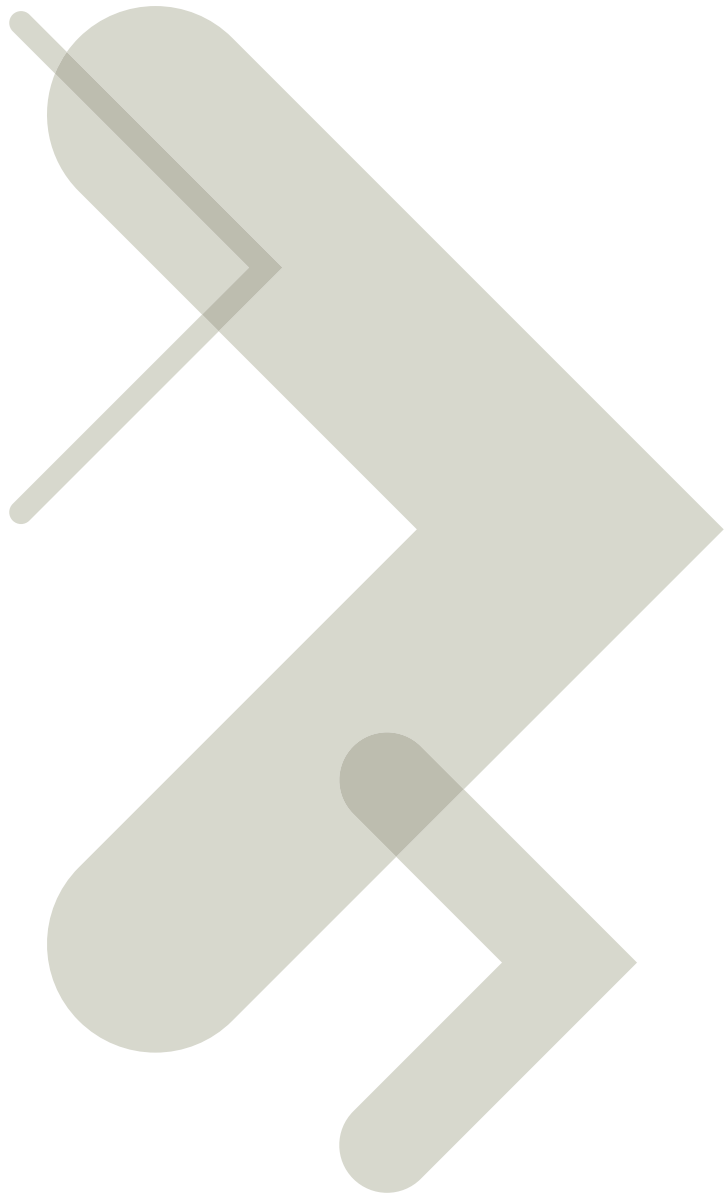




# Femtocells — The Gateway to the Home





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## Abstract

Femtocells are small, low-cost cellular base stations optimised for use in the home and small businesses. This paper discusses this exciting new market and concludes that femtocell and Wi-Fi technology will co-exist, rather than compete, to deliver a comprehensive digital home experience.

It describes how femtocells will enhance the delivery of telecommunications services in the home and the new possibilities arising from the integration of femtocells with home gateways and set-tops. It will also point out technical challenges cable operators must assess and outline the opportunities for cable operators to complement cable access infrastructure with femtocells to enhance market share and customer retention through enhanced triple play and quad play services.

## A Femtocell Overview

Femtocells — miniature cellular base stations that connect via broadband infrastructure to provide enhanced 3G signal within the home — represent arguably the most exciting development in home networking since the arrival of Wi-Fi®.

Interest in femtocell technology is reflected by growing activity among telecom operators and hardware vendors alike. Research firm IDC predicts that spending on femtocell-enabled services will grow to \$900 million by 2011.

The unique demands of a high-performing femtocell ecosystem demands competence in several key areas, a combination of expertise not previously required from a single cellular infrastructure product:

- It must perform in a hostile RF environment.
- It must meet the high expectations of a mature cellular subscriber base.
- It must integrate seamlessly with existing access networks.
- It must be capable of being deployed and supported in high volume.
- It must extract maximum performance from network backhaul, and it must be capable of being remotely managed without excessive operator effort.

These “must have” attributes demand a skillset that cable operators can rely on for delivering end-to-end femtocell solutions that increase Average Revenue Per User (ARPU), grow market share, and enable innovative partnerships with wireless service providers that increase brand value and allow cable operators to develop innovative triple play and quad play services.

## Standards Integration

Femtocell technology is very new, and developments are fast moving and exciting. As a consequence, product development is far ahead of standardization. Broadband operators require that new femtocell deployments rely on industry standards to enable smooth integration and the ability to deliver seamless mobility of voice and data services.

If the femtocell market is to grow as expected, the evolution of common standards is the best way to achieve this. The interface between the femtocell Customer Premises Equipment (CPE) and the femtocell aggregator (sitting in the operator’s headend or central office) is key to interoperability.

This is also the interface that is most open to interpretation, so it is important to monitor the evolution of industry standards. Motorola is very active in the standards bodies to move this debate forward, but, in the meantime, Motorola supports two subtly different versions of the CPE-aggregator interface within the company’s femtocell product portfolio. Femtocell trials are being conducted this year, with commercial launches expected to begin in late 2008 or 2009.

## The Need For Femtocell Deployments

Femtocells will deliver home broadband communication like never before by enabling personal devices to perform seamlessly in and out of the home. Connecting to the mobile network via a gateway over an existing broadband connection, femtocell solutions make indoor coverage for mobile communications truly pervasive while delivering additional benefits to both the service operator and the end-user.



### Femtocell coverage solution

A femtocell is a small, low-power, self-installed cellular base station optimized to deliver cost-effective coverage in the home and small office environment. Once installed in a customer's home, it enables the operator to provide higher-quality and higher-performance wireless voice and real-time data services to their customers inside their homes. Today, 3G is the focus for femtocell technology. The full 3G service set can be delivered in the home from a small stylish device, which is connected to the mobile operator's core network using open 3GPP based standards via the consumer's HFC connection.

Femtocell products require extensive experience in collapsed architectures, RF techniques, home gateways, CPE management, and fixed-mobile solutions to enable cable operators to launch new services with fast time-to-market and low risk. Femtocells are aimed at providing high-performance 3G voice and data communications in and around the immediate home environment. Connected to the operator's mobile network over existing broadband connections in the home, femtocells have the potential to make indoor coverage for mobile communications truly pervasive while delivering additional benefits to both the operator and end-user.

The femtocell network architecture provides operators with a complete indoor coverage solution, all in a small, low-cost, low-power, easy-to-install base station that can be seamlessly integrated into existing mobile networks and provisioned for service within minutes of switching it on. Such platforms enable a host of new applications and revenue opportunities, and provide cable operators with the means to prevent the loss of subscribers to carriers offering bundles of wired and wireless access services.

Femtocell allows cable operators to aggressively enter the fixed/mobile convergence market. Femtocell deployments will address the driving need for seamless mobility of voice and data service.

### Addressing Subscriber Pain Points

Every consumer of wireless voice services has had the experience of being on an important wireless phone call and losing their cell signal. In light of that consumer pain, femtocell technology is arguably one of the most exciting developments in home networking since the arrival of Wi-Fi — both enable operators to better meet consumer demands for seamless connectivity. The low-power, wireless femtocell access points are optimized for use in the home and small businesses, connecting via broadband to provide an enhanced 3G signal within the home.

Femtocells, which may look like a stand-alone consumer device sitting on a kitchen counter, actually function as part of the provider's network infrastructure. Consumers primarily use their mobile phones at home, even when they have a fixed-line telephone. People, especially younger consumers, have become accustomed to the mobility conveniences of a single communication device.

Additionally, more people would prefer one number and one device to handle all their communications needs, whether they are in the home or at work or play. An October 2007 survey commissioned by FusionOne, Inc., a mobile content backup services provider, found that more than half of respondents indicated that their social lives would "suffer" if their mobile phone were to go missing.

Most wireless operators agree that a significant proportion of all calls made from mobile phones are initiated indoors, so it becomes understandable why providing good indoor coverage is essential to provisioning cost-effective, high-quality, and higher-performance wireless voice and data services to consumers.

When subscribers at home connect to the wireless operator's mobile network over existing network infrastructure, it allows operators to make mobile communications truly pervasive, creating long-term bonds with subscribers that minimize churn and enabling new revenue opportunities from bundles mobile and broadband service packages.

### Femtocell Benefits for the Cable Operator

Femtocells enable operators to provide higher-quality and higher-performance wireless voice and real-time data services to their residential and small home office customers. They will be able to offer subscribers high-quality 3G services at lower costs while they are in their homes. In addition, they enable a lower cost of delivery of wireless traffic in comparison to the macro cell network. Femtocells can be used as part of integrated triple or quad play services, which meet consumer communication needs and increase the operator's competitiveness and ability to retain customers.

The integration of broadband and femtocell technologies will allow broadband operators to fend off attacks from competing carriers, create longer-lasting relationships with subscribers, and drive new revenue growth by offering attractive seamless mobility services. Femtocells have an important role to play in driving premium mobile service adoption, finally turning the 3G service vision into a reality by encouraging a culture of usage through low-cost, high-performance mobile data services.

### Femtocell Benefits to the Customer

For consumers, the benefits of femtocells include:

- A seamless communication experience as customers roam from inside to outside their homes.
- Greater convenience via effective fixed-mobile substitution that eliminates the need for separate home phones, offering consumers the flexibility of a single phone for access on the road or at home.
- Reduced in-home call charges.
- Excellent indoor coverage.
- Lower-cost voice calls from within the home.
- Consolidated billing for voice and data services.
- The convenience of using a mobile handset with its personal phonebook and other cool handset features, without the concerns of poor call quality or additional cost.

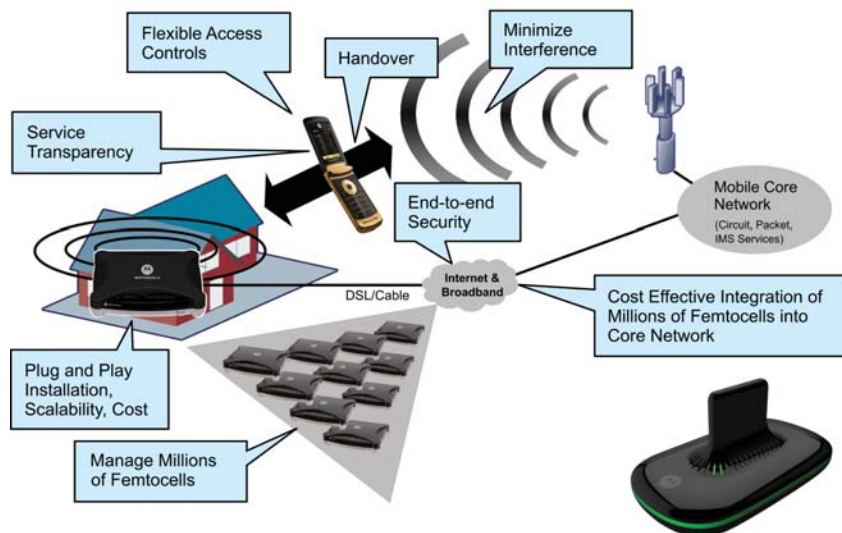
### Addressing Technology Challenges

The successful deployment of femtocell technology can bring great rewards, but require that broadband operators overcome diverse technology challenges.

Operators face significant challenges with the deployment of new technology, new applications and the ever-increasing usage demands placed upon mobile networks. At the forefront of these challenges is making 3G coverage as "near ubiquitous" as practically possible, both outdoors and indoors.

The traditional 3GPP 3G network architecture, made up of numerous macro base-stations, with its centralized RNC function and ATM backhaul was designed to provide wide-area coverage. It was not however designed to scale, physically or economically, to provide effective coverage for individual indoor/residential situations.

## Femtocells Present Many Unique Challenges



Broadband operators can make a compelling value proposition for partnering with mobile operators. It is common knowledge within the mobile telecommunications industry that the use of outdoor macro-cells to provide indoor/residential coverage quite simply does not provide an effective solution, from both a coverage and economic perspective. It also impacts practical matters, such as site acquisition, which is becoming increasingly problematic.

Not only is site acquisition costly, forming a major proportion of network build-out costs, it is also very time consuming because many local authorities closely regulate the sale and usage of potential cell-sites. Assuming suitable sites can be acquired, increasing cell-site density through the use of smaller cells may not overcome all coverage issues but will lead to increased backhaul costs and other practicality issues.

People are becoming increasingly reliant on their handset device to the extent that it forms “part of their identity;” similarly, more and more people would prefer one number and one device to handle all their communication needs, be it in the home or elsewhere. Many end-users prefer to use their mobile phone when in the home, even where a fixed-line telephone is available. People have become accustomed to, and indeed take for granted, the convenience that the mobile phone provides: primarily in terms of mobility, but also through the convenience of having a single device that includes their contacts and even takes and stores their messages in a variety of formats.

3G signals, operating at very high frequencies and high bandwidths, penetrate through structures poorly. This often leads to service quality and service experiences that do not meet end-user expectations and can lead to dissatisfaction, reduced minutes of use, increased customer churn and, ultimately, lost revenues.

Most end-users of 3G services invariably have to settle for the coverage provided by the macro base-station serving their location at that point in time, whether stationary out in the world, in a building, or while on the move. The issues associated with providing coverage for indoor situations from macro base-stations are well known; 3G and buildings, or to be precise their fabric, are inherently not a good mix.

Since late 2006, interest in femtocell solutions has increased to the extent that most industry analysts suggest femtocell deployment will become widespread in the coming years.

### **Femtocell Considerations and Characteristics**

Having considered the major drivers for femtocell deployment, this section looks at some of their practical aspects. Femtocells overcome the issue of providing effective indoor coverage from the 3G-macro layer by their placement in the end-users’ homes. Once installed in an end-user’s home, a femtocell will enable the cable operator to provide higher-quality and higher-performance wireless voice and 3G data services in and around the immediate vicinity of the home environment.

Femtocell products are in many ways similar to Wi-Fi access points in that they enable access through an unobtrusive device; however femtocells enable full 3G service delivery in the home. Similar in size to a cable modem, a femtocell is a low-capacity base-station, radiating only sufficient power to cover the area of a home environment. The femtocell connects to the operator’s core network using open 3GPP-based standards through the end-user’s household broadband Internet connection rather than traditional cellular backhaul methods. Accordingly, femtocells must also fulfill a number of other criteria:

**Low-impact** — Space may be limited for some households. As a result, femtocells must be physically small, aesthetically pleasing, and easy to position. Furthermore, they should also be silent in operation, generate low levels of heat output, and be inexpensive to run in terms of on-going electricity costs.

**Low RF power** — The transmit RF power output of femtocells is low, typically less than 10 mW. Put in perspective, this is a lower power level than many Wi-Fi access points, which transmit at 100 mW of output power. Additionally, by being close to the femtocell the 3G handset itself is able to transmit at lower power levels than it might otherwise have to when on the macro network.

**Capacity** — Femtocells are aimed at delivering dedicated 3G coverage to a household and, in doing so, can provide a very good end-user experience within the home environment. As a result, femtocells have a design capacity of up to 20 registered users and 4 simultaneously active calls.

**Low-cost** — There is significant competition for access solutions in the home space. Wi-Fi is commonplace and easy to install/configure. Femtocell platforms in the home should compare favorably with Wi-Fi base stations in cost and performance.

**Low-power consumption** — Clearly, if the end-user is to foot the bill for the electrical energy consumed by the femtocell base-station, then this figure must be low enough not to raise concerns as to its impact on the fuel bill.

**Easy end-user installation** — Like cable modems and DSL routers, consumers will install femtocells and service providers will activate them. This means that the cable operator will not have to employ installation teams or have a truck-roll every time a new femtocell is deployed. From the end-user perspective, the unit must be a simple “plug and play” installation with a minimal amount of intervention required.

**Interference** — The use of femtocells in spectrum also currently used by the macro layer may, if not managed correctly, give rise to issues with interference between cells; macro with femtocell and, in the instance of close proximity of two or more units, femtocell with femtocell. Operators will likely want to launch femtocells on the same channel as macro cell networks for capacity reasons.

**Handovers** — Current macro RF planning techniques are inappropriate for femtocells because of the sheer potential numbers of femtocells. Also, the potential to “ping-pong” between layers, especially as an end-user moves around the home and enters into areas where the signal strength from the macro-cell is greater than that of the femtocell, must be considered very carefully to ensure that the networks provide the best overall coverage without issue. Femtocells introduce new complexities in macro to Femtocell, Femtocell to macro, and Femtocell to Femtocell handover scenarios.

**Security** — Given the requirements for low-cost and easy installation, the use of the broadband Internet as the network interface becomes very easy to understand. However, this raises security risks in that broadband Internet has open access. There are various approaches to address this issue, including the embedding of the interface within the IP signaling itself while network security is managed by the IP security (IPSec) protocol.

**Worldwide cellular network standards** — Understandably, femtocell products are likely to appeal to many end-users around the world. As a result, differing models will be developed and offered to satisfy the various needs from the different regions. Products should offer support for their respective and existing (3GPP) UMTS and (3GPP2) CDMA standards, as well as emerging standards such as Imax, UMB, and LTE.

**Support for existing 3G handsets and devices** — Support for existing handsets and devices is a very important consideration for the end-user and operator alike. In each technology market, femtocells will support existing handsets and devices, further helping to drive uptake of 3G services and femtocells in particular.

**Operator control** — Femtocells operate in licensed spectrum and, as such, broadband operators must ensure that they comply with regulatory requirements. Femtocells need to feature client software that enables remote configuration and monitoring via a centralized Operations, Administration, Management, and Provisioning (OAM&P) system.

**New services and applications** — Femtocells are likely to become an integral part of managing all communications in and out of the home environment. They will enable broadband operators to cost-effectively offer in-home pricing and integrate mobile services into triple-play / quad-play service offerings. Femtocell architectures will need to include provisioning for a complex service environment on which applications may be added, thereby facilitating new revenue opportunities.

**Service Assurance** — Remote management is needed to enable an operator to provide the end-user quality of service needed at the edge of the network.

## Industry Trials

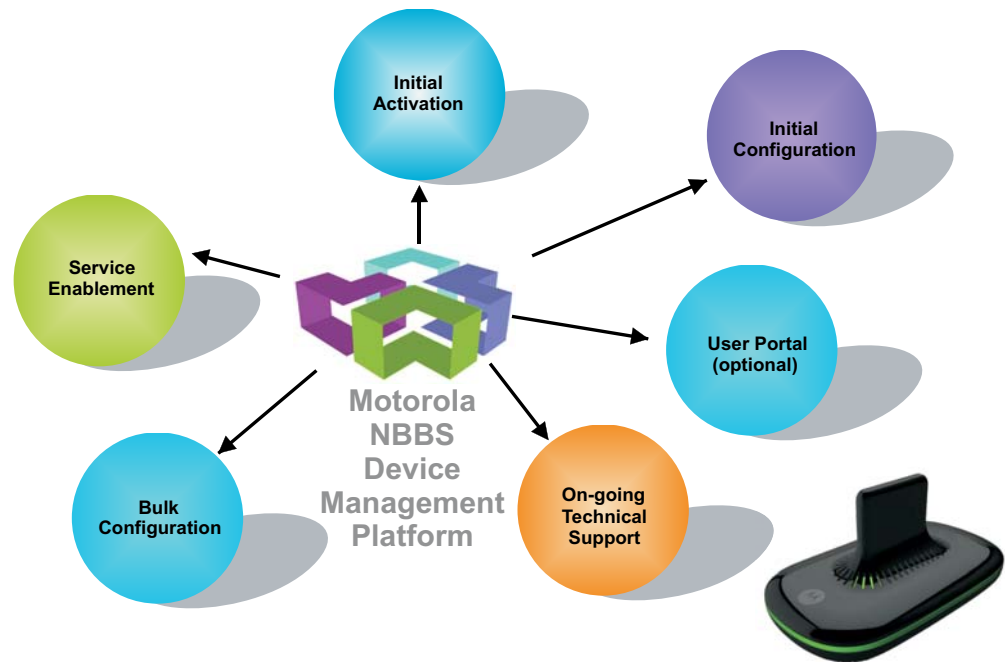
Broadband operators can turn to the following URLs for up-to-date information on femtocell technology:

- [www.femtoforum.org](http://www.femtoforum.org)
- [www.motorola.com/femtocell](http://www.motorola.com/femtocell)

While the previously mentioned criteria and challenges are being addressed throughout the industry, femtocell testing and deployment continue to happen around the world. Selecting equipment vendors with experience in femtocell trials is essential, and trials are now underway primarily in Europe and North America.

These developments and the industry’s early groundwork are leading toward the realization that as technical and commercial challenges are resolved, a femtocell in every home could become a reality.

# Remote Management and Service Delivery Platform



## Femtocell Management

Broadband operators need software platforms that will allow them to remotely access, configure, and troubleshoot the full portfolio of consumer devices, including mobile phones, CPE, and femtocells. This helps to lower operators' costs by reducing truck rolls and lowering operational expenses. It also helps to increase revenues by accelerating new service introduction.

Scalable, carrier-grade systems are needed that can manage devices, home networks, and services. Operators deploying femtocell solutions will need to deliver an excellent end-user experience, and they need centralized OAM&P systems that enable the efficient provisioning, management, and operations of femtocell solutions. Centralized control is essential so that broadband operators can deliver an excellent user experience while minimizing support costs and swiftly generating revenues from mobile services.

Operators need the ability to centrally automate service provisioning, upgrade femtocell platforms at customer locations, and activate and support residential subscribers without bearing the burden of unnecessary truck rolls.

## End-to-End Femtocell Solutions

Broadband operators implementing femtocell connected home solutions can deliver highly differentiated services that drive revenue growth and lead to longer-term relationships with subscribers. Considering that the majority of mobile calls originate in the home and end-users prefer to use a single handset, cable operators can now turn to emerging solutions available to them that overcome the issues of poor in-building coverage.

Until now, providing good mobile coverage for homes has largely been overlooked. That is changing. Femtocells will provide a one-box solution: a small, low-cost, low-power unit that can be self-installed to provide mobile 3G coverage to the home.

For the end-user, femtocell solutions will provide dedicated and reliable mobile 3G coverage in the home with opportunities for preferential tariffs. For the broadband operator, femtocells deliver cost-effective coverage and new revenue and customer satisfaction opportunities.

Once in the home, the femtocell is likely to encourage end-users to use their mobile as their single communications device irrespective of their location. Femtocell solutions are also likely to increase minutes of use and ARPU and also open up brand-new revenue streams for cable operators through the integration of mobile services into triple-play and quad-play service offerings. Broadband operators need to minimize the risk of deploying new technologies by relying on vendors that already have proven expertise in the many technology areas required for successful femtocell deployment.

Solutions, however, are not simply about technology only; they are also about capabilities and delivery. That's why operators need access to expert professional services to deploy femtocell solutions that leverage existing wireless standards.

End-to-end femtocell solutions will allow cable operators to differentiate their service offerings by providing seamless mobility and allowing subscribers to access voice and data services as they move throughout the connected home.

While femtocell technology offers great promise, selecting equipment from the right vendor is key to successfully launching new services. Broadband operators should rely on fully integrated and tested end-to-end solutions based on open standards, which include:

- A range of low-cost, easy to deploy CPE.
- A core network concentrator.
- A centralized management and provisioning system.

By relying on proven technologies already tested in femtocell trials, broadband operators can safely explore the value of seamless mobility by offering integrated voice and data services available throughout the home over wireless cellphones and PDAs.

Connected home solutions that leverage emerging femtocell technology will enhance the user experience, allowing the operator to increase ARPU through better home coverage and new multimedia and location-based applications. Selecting vendors experienced in delivering high-volume CPE for both mobile and fixed networks is crucial, and the ability to develop and manage end-to-end femtocell solutions will allow operators to prosper by enabling the future of the connected home.



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