FEMTOCELL
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**Conclusion**
Evolution of femtocell

The first interest in femto cells started around 2002 when a group of engineers at Motorola were investigating possible new applications and methodologies that could be used with mobile communications. Further after 2yrs. In 2004 more attention was given to this technology and it was enhanced further.

What is a Femtocell?

Mobile cellular and 3G networks normally often suffer from poor penetration and reception in certain areas, like indoors. This decreases the quality of voice and video communication and slows down high-speed services. A femtocell is a small device that is used to improve wireless coverage over a small area, mostly indoor. It is a small cellular base station, also called a wireless access point that connects to a broadband Internet connection and broadcasts it into radio waves in its area of coverage. As a result, mobile handsets can handle phone calls through the femtocell, via the broadband Internet connection.

The name femtocell has the prefix ‘femto’, meaning a very small cell (area of network coverage). Small is rather a big word here, because femto denotes a division that is mathematically represented by 10 raised to the power of -15, or a quadrillionth. In plain English, it is one divided by a figure with fifteen zeros. Well, close to infinitely small.
**Femtocell Definition**

Femtocell is a small cellular base station, designed for use in residential or enterprise. It connects to the service provider’s network via broadband. It supports 2 to 5 mobile. It allows service providers to extend service coverage indoors.

A femtocell is a small device that is used to improve wireless coverage over a small area, mostly indoor.
Need of femtocell

Mobile cellular and 3G networks normally often suffer from poor penetration and reception in certain areas, like indoors. This decreases the quality of voice and video communication. It slows down high-speed services.

Problem-3G Coverage Issues:

- 3G cells are smaller by virtue of supporting higher data rates
- 3G infrastructure needs to Proliferate
- Femtocells are a vehicle for expanding 3G coverage and improving indoor coverage
- Infrastructure must evolve to support millions of small cells

Third-generation cellular technology suffers from inadequate indoor-signal penetration, leading to poor coverage in the environment where consumers spend two-thirds of their time. Poor coverage diminishes the quality of voice and video applications, and slows down high-speed data services. To keep customers satisfied, 3G carriers have increased capacity by building additional microcell sites. This strategy is becoming much less attractive. Site acquisition costs are exorbitant and continue to mount as space on viable towers and buildings fills up, landlords exact high rents and regulators impose onerous permit requirements. Public opposition to the building of large-scale base stations is increasingly common.

Acquiring a site is only half the battle: Sophisticated base station equipment must then be purchased, installed, insured, operated and maintained. The net present value of a cell site in the U.K. is estimated to be $500,000. Carriers thus face a serious dilemma. Well it's clear more and more consumers want to use mobile phones in the home, even when there’s a fixed line available. Friends and family usually call a mobile number first, and it's where messages and contact lists are stored. However, it is often the case that providing full or even adequate mobile residential coverage is a significant challenge for operators.

From a competitive perspective, femtocells are important because mobile operators need to seize residential minutes from fixed providers, and respond to emerging VoIP and WiFi offerings. Improving user experience in the home is also essential for reducing churn and gaining marketshare and new revenues. However, high deployment costs ensure that 3G networks rarely extend beyond the regulatory minimum. Using femtocells solves these problems with a device that employs power and backhaul via the user’s existing resources. It also enables capacity equivalent to a full 3G network
sector at very low transmit powers, dramatically increasing battery life of existing phones, without needing to introduce WiFi enabled handsets.

- Indoor cellular coverage
- Can “talk” with any handset device
- Low cost backhauling
- More than 50% voice calls and more than 70% data traffic are originated indoor
- The 3Cs--coverage, churn and capacity--are stifling 3G adoption.
- Femtocells produce cost savings as well for the carriers. Consumer's home in essence becomes a cell site and there is no site acquisition costs involved.
- Electricity bills can be minimized.
- Unlimited mobile minutes for a fixed monthly fee.

Other solutions:
- Repeaters
- Dual Mode WiFi
- Femtocells

Why Femtocell?
The 3Cs--coverage, churn and capacity--are stifling 3G adoption. Femtocells produce cost savings as well for the carriers. Consumer's home in essence becomes a cell site and there is no site acquisition costs involved. Electricity bills can be minimized. Unlimited mobile minutes for a fixed monthly fee. The call charges can also be reduced based on which subscriber we are using. Provides better coverage and also prolonged battery life compared to others. Portable and easy to install and use.

Speed:
- 2.5 G

The femtocell will be 2G GSM technology, supporting data services through GPRS and EDGE which typically offer up to 384kbit/s.
- 3G UMTS

Femtocells add network capacity and make it possible to deliver 7.2 Mbps and 14.4 Mbps data rates to consumers in indoor environments.
Concept of Femtocell

- Indoor cellular coverage
- Can “talk” with any device
- Low cost backhauling

Features of Femtocell

- Operates in the licensed spectrum
- Uses fixed broadband connection for backhaul
- Principally intended for home and SOHO
- Lower cost
- Smaller coverage
- Smaller number of subscriber
- Higher density
Working of Femtocell

Femtocells from part of the mobile operation’s network, although they are located at home or in the business. Most of the functionality of a completer 3G cell site has been miniaturized onto a chip, which look and operates like a WiFi access point, and is connected via broadband DSL back to the mobile operator’s network. A femtocell is installed at home and connected to mains power and a standard broadband IP connection (typically DSL) through to the mobile operator’s core network. Voice calls, text massages and data services are provided by the same systems.

Femtocells operate at very low radiation power levels (50 milliwatts peak output during a call, much lower when idle), and typically have a range of 200 meters. The signals do not travel through walls particularly well, but this is a benefit because it allows the frequency to be reused for other calls in nearby building. Where users walk outside or out of range, calls are automatically handed over to the external mobile network. Any standard 3G phone can be used on the femtocell if permitted by the mobile operator. Unlike WiFi access points, 3G Femotcells operate using licensed spectrum and thus must be supplied and operated in conjunction with the mobile operator Figure 1 shows working of femtocell.

The battle is most likely to be between the modified 3G RAN (which some RAN Network vendors are keen to promote because it reuses their existing RNC products) versus UMA, which has new, custom designed systems architected to handle the much larger number of cells and IP connectivity. SIP based solutions may be of interest where the user wants to bypass the network operator

When registered handsets enter the range of a femtocell, handing over to the femtocell network is done automatically, such that calls are channeled through the broadband connection. One femtocell can support up to 5 mobile handsets.

Femtocell technology, which is another block in the Fixed-Mobile Convergence concept, is still in its early days and it is receiving fierce competition from UMA and Wi-Fi technologies. For instance, one might ask why invest in femtocells when a cheap Wi-Fi router can do the work with a Wi-Fi supporting handset, given that handsets supporting Wi-Fi are becoming more common and are being shipped by hundreds of millions.
**Design of Femtocell**

The following are the key features that are to be considered as the characteristics of femtocell in the design of femtocell.

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

**Low RF power** - The transmit RF power output of femtocells is low; between 10 and 100 milli-watts. Put in perspective, this is a lower power level than many Wi-Fi access points, which can be specified up to 1 Watt of output power. Additionally, by being close to the femtocell the 3G handset is itself 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 enduser experience within the home environment. As a result, femtocells have a design “capacity” of up to 6 end-user.

**Low-cost** - There is significant competition for access solutions in the home space. Wi-Fi is commonplace, easy to install/configure, provide a very good benchmark in terms of performance, and are highly cost effective. Femtocells will be offered for purchase via their Operators. This may be direct or through resellers.

**Energy offset** - 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. That said, from an Operator’s perspective, this OPEX is effectively offloaded, which makes the business case for femtocells even more attractive.
**Easy end-user installation** – Like cable modems and DSL routers, femtocells will be installed by consumers and activated through service providers. This means that the Operator no longer has 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.

**Backhaul via broadband** – Femtocells utilize Internet protocol (IP) and flat base-station architectures. Backhaul connection to Operator networks will be through wired broadband Internet service existing in the home such as DSL, cable, or fiber optics as available. There are no connections required to the wider cellular network other than through the IP core. This will benefit Operators by effectively offloading traffic that would otherwise be on the macro-layer directly onto the internet from the femtocell; this not only reduces the load on the core network but also lowers the cost of delivering wireless traffic when compared to the macro network.

**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 their macro cell network for capacity reasons.

**Handovers** - Current macro RF planning techniques are inappropriate for femtocells. Not least because of the sheer potential numbers of femtocells and managing the neighbor lists that would be necessary. 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. To illustrate, in macro based 3G networks the overhead associated with softhandovers accounts for a significant proportion of RNC processing capability. Understandably then and in order not to exacerbate the issue, great care and sophisticated algorithms are necessary to overcome these potential issues and ensure that the over-all network quality is not impacted by inefficient handovers and wasted capacity.

**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 lub interface within the IP signaling itself while network security is managed by the IP security (IPSec) protocol.

**Worldwide cellular network standards support** – Understandably femtocell products are likely to appeal to many endusers around the world. As a result differing models will be developed and offered to satisfy the various needs from the different regions. Products will offer support for their
respective and existing (3GPP) UMTS and (3GPP2) CDMA standards, as well as emerging standards such as WiMAX, 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, not least because of the cost of changing devices if that were necessary. In each technology market, femtocells will support existing handsets and devices further helping to drive uptake of 3G services and femtocells in particular.

**Operation (transmit/receive) in Operator-owned spectrum** – Femtocells operate in licensed spectrum owned by Operators and may share the same spectrum (currently the 2100MHz frequency band) with the macro network.

**Operator controlled** – Femtocells operate in licensed spectrum and as such Operators must ensure that they comply with the conditions of that license and any other controls enforced by a regulator. To these ends femtocells feature client software that enables remote configuration and monitoring via an Operations, Administration, Femtocells Maintenance and Provisioning (OAM&P) system in a similar manner to that used by the macro network.

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

**Service Assurance** – Remote Management to enable an operator to provide the end-user quality of service at the edge of the network.
OSI Model

Physical Layer

In computer networks the OSI Physical layer provides the means to transport across the network media the bits that make up a Data Link layer frame by many devices such as switch or hub. Also, it is concerned with which type of media you can choose to transmit your data. There are three basic forms of network media on which data is represented:

- Copper cable
- Fiber
- Wireless

The Physical layer consists of hardware, developed by engineers, in the form of electronic circuitry, media, and connectors. Therefore, it is appropriate that the standards governing this hardware are defined by the relevant electrical and communications engineering organizations. The various standardization for femtocell as follows:

- International Telecommunication Union (ITU),
- European Telecommunication Standards Institute (ETSI),
- Internet Engineering Task Force (IETF),
- 3rd Generation Partnership Project (3GPP),
- and Digital Subscriber Line (DSL) Forum

Regarding to Femtocell networks, this technology can be illustrated when its processes are organized as layers. Femto Access Point (FAP) is considered as a physical layer device which responsible for connecting to the service provider’s network via broadband (such as DSL or cable). This device serves 4-5 users and will cover a radius of 50-200 meters.

It is better to describe the specifications of the Femtocell Network.
Data link Layer

This layer plays an important role for transferring frames for many users. To control on this issue, there is a unique address defined by the manufacturer on each FAP (Femto Access point). This address which is called “cell ID” allows each FAP to be known at the other end like core network and this idea will be more clear when we talk about network layer. Regarding to this address “cell ID”, it consists of 16 bit.

Network Layer

As we mentioned before, Femtocell Networks provide the user a wireless coverage to the mobile phones by connecting to the macro cell access (core network) using a DSL, cable or fiber optic. However, this process is not appropriate when many FAPs are connecting to the core network since these FAPs may be interface to each other while they are communicating to the core network especially at the same time and none of the users will benefit from this technology. Also, this core network has a limited capacity to serve million of users according to its design and it cannot exceed this limitations. Definitely, nowadays within the increase in mobile usage, operators are forced to plan for increased capacity and coverage. But they have many problems like a site acquisition and it is not easy and very costly more than constructing a macro cell network[2].
So, a new device is developed to avoid this traffic which is Iu Concentrator or femtocell gateway device (FGW). It is used to scale the limited capacity of core network to million of femtocells.

Regarding to assessing femtocell network Architecture and how the FAPs are communicating to the FGW, the whole process will be introduced in points as follow:

- First of all, FAPs are communicating with FGW by their cell ID (16 bits)
- FGW multiplexes the traffic coming from different FAPs and forward it to the Radio Network Controller (RNC) by using (FP) protocol as shown in fig. Also, FAP establish a security association with the FGW to avoid compromising subscriber information over the public IP network.

**Transport Layer**

RNC handle all the resource management and control functionality; the RNC and FGW together would take care of delay for traffic and control signaling (specifically forced/hard handover mobility management) caused by the underlying public IP network. The core network (CN) has mobility management protocol (MM) and call control protocol which is operated in the core network.
The agreed 3GPP HNB architecture follows an access network-based approach, leveraging the existing Lu-cs and Lu-ps interfaces into the core service network. The architecture defines two new network elements, the HNB (a.k.a. Femtocell) and the HNB Gateway (a.k.a. Femto Gateway). Between these elements is the new Lu-h interface.

**Home NodeB (HNB)** - Connected to an existing residential broadband service, an HNB provides radio coverage for standard 3G handsets within a home. HNBs incorporate the capabilities of a standard NodeB as well as the radio resource management functions of a standard Radio Network Controller (RNC).

**HNB Gateway (HNB-GW)** - Installed within an operator’s network, the HNB Gateway aggregates traffic from a large number of HNBs back into an existing core service network through the standard Lu-cs and Lu-ps interfaces.

**Lu-h Interface** - Residing between an HNB and an HNB-GW, the Lu-h interface includes a new HNB application protocol (HNBAP) for enabling highly-scalable, ad-hoc HNB deployment. The interface also introduces an efficient, scalable method for transporting Lu control signaling over the Internet.
**Classification of femtocells**

Since a large number of femtocells can be installed by subscribers, in certain scenarios femtocell access shall be restricted to certain subscribers who are authenticated and authorized for exclusive access and related network service.

Additionally, femto BS can provide a mechanism delivering initial access information (e.g. BS ID, frequency, closed group information, NSP, roaming capability) of its own and neighboring femto BSs to any MSs in order to facilitate their network discovery/selection and entry procedure to femtocells.

Femto BS can be classified into 4 types:

- **Based on bearer connection capability**
  - Open femto BS: Provides bearer connectivity (full network services) to any MS
  - Closed femto BS: Only provides bearer connectivity to allowed (identifiable) MSs

- **Based on initial access information capability**
  - Initial access able femto BS: Provides initial access information for any MSs
  - Initial access unable femto BS: Not allow to provide initial access information
**FemtoCell Open Areas and Challenges:**

Femtocells are a complicated technology and there have been a number of issues and concerns which need to be addressed:

- Radio and interference issues
- Handover and mobility management
- Synchronization and localization
- QoS and Security issues
- Controversy on consumer proposition
- Equipment location

**ISSUES**

**Interference**

- The placement of a femtocell has a critical effect on the performance of the wider network, and this is one of the key issues to be addressed for successful deployment. Because femtocells can use the same frequency bands as the conventional cellular network, there has been the worry that rather than improving the situation they could potentially cause problems.
- As more analysis has been done, and more operators have deployed it is clear that so long as femtocells incorporate appropriate interference mitigation techniques (detecting macrocells, adjusting power and scrambling codes accordingly) then this need not be a problem.
- DL interference
- MS is affected by Macro/Femto BSs if it locates in the area covered by Macro/Femto BSs
- UL interference
• Femtocell may be affected by the neighboring MS(s) which associates with different Macro/Femto BS(s)
• In order to find out the DL interference situation, MS needs to report the scan result to which it is associated.
• In order to find out the UL interference situation, BSs should exchange the scan reports.

Controversy on consumer proposition
• The impact of a femtocell is most often to improve cellular coverage, without the cellular carrier needing to improve their infrastructure (cell towers, etc.). This is net gain for the cellular carrier. However, the user must provide and pay for an internet connection to route the femtocell traffic, and then (usually) pay an additional one-off or monthly fee to the cellular carrier. Some have objected to the idea that consumers are being asked to pay to help relieve network shortcomings. On the other hand, residential femtocells normally provide a 'personal cell' which provides benefits only to the owner's family and friends.

Quality of service
• In shared-bandwidth approaches, which are the majority of designs currently being developed, the effect on Quality of Service may be an issue.

Equipment location
• There are issues in this regard for access point base stations sold to consumers for home installation, for example. Further, a consumer might try to carry their base station with them to a country where it is not licensed.
• Other regulatory issues relate to the requirement in most countries for the operator of a network to be able to show exactly where each base-station is located, and for E911 requirements to provide the registered location of the equipment to the emergency services.
**Handover Operation**

Handover (called handoff in the US) is the process by which a mobile phone switches between different call sites during a phone call, continuing with seamless audio in both directions. One of the most complex aspects of mobile phone systems. Femtocell users need this capability when entering or leaving their home – perhaps a rare use case, but essential nonetheless.

**Handover in Mobile Phone systems**

As a person move around when on a call, your mobile phone continuously measures the signal level and quality from nearby cell sites. These measurement reports are streamed to the current active base station, which determines when and where to initiate a handover sequence. Complex algorithms are used when making these judgments, in order to ensure that best use is made of all available capacity while reducing the likelihood of dropping a call during (or by postponing) a handover. In the case where connection to the current active cell site is dropped, the system is smart enough to allow the mobile phone to request a new connection on a different cell site and reconnect the call. This typically causes a short break of up to a few seconds in the conversation. If the call cannot be reconnected, then it drops out.

3G systems are slightly more complex because it is possible for a mobile to be actively connected to more than one cell site at the same time. This feature, called soft handover, allows the same signal transmitted by a mobile phone to be picked up by multiple cell sites and the best quality reception selected on a continuous basis.

**Femtocell Handover**

Femtocells do not implement soft handover, regardless of the radio technology used. Instead, all calls are switching instantly to or from the femtocell and the external outdoor cellular network. This is known as “hard handover” and would typically not be audible or noticeable to the caller.

The 2G and 3G systems from the same mobile network co-exist, as is very common with GSM and UMTS, and then handover between 2G and 3G can also occur. Operators prefer to use 3G systems because of the higher traffic capacity and lower costs. Their systems are therefore configured to automatically select 3G where good reception is available, reverting to 2G when out of coverage – typically either in a rural area or inside building where 3G signals can’t so easily penetrate (due to operating at higher frequencies and having fewer 3G call sites thus being further away).

Many 3G femtocells are also capable of 2G GSM reception. 2G typically penetrates buildings better than 3G, it allows the femtocell to determine where it is (by reading the cell site identification on its broadcast channel),
derive some timing/clocking reference (as one input to its timing algorithm), and work out which 2G cell sites might be most appropriate to handover to when a mobile phone leaves the femtocell zone. Presumably, these 2G cell site identifies can then be transmitted to the mobile phone as potential handover candidates (known as the neighbor list), and be measured during any active call in case a handover is required.

**Optimizing Handover into a Femtocell**

There are potentially three approaches to optimizing handover into a femtocell:

1. **Adding femtocells to the neighbor lists of the outdoor macro cells:** This is unlikely to be as scalable or workable solution. Although neighbor lists can be quite large, the time taken to scan round many different settings increases proportionally. In dense urban areas, there may potentially be some 100’s of femtocells collocated with an outdoor macro cell. The mobile phone would not be searching for the most likely cell site to switch over to, and dropped calls would increase. Additionally, the complex management to download and maintain vast numbers of femtocell candidates add an overhead to the network operator.

2. **Adding some smarts into the mobile phone:** One of the key benefits of femtocells is that they work with any standard 3G phone – this is a clear competitive advantage compared with WiFi dual-mode solutions that are restricted to specific (and sometimes more expensive) dual mode devices. However, it could be argued that with some additional functionality in the phone itself, then improved handover into the femtocell zone is enabled. For example, the phone could learn about its femtocell zone and the matching external cell site used outside. When on a call in the external cell site it could additionally monitor for the femtocell and switch across to it when in range.

3. **Making the femtocell as clever as possible:** Ensuring that any calls about to dropout when entering the femtocell zone are quickly restored as soon as the mobile can detect and lock-on to the femtocell. Parameter selected by the femtocell, such as the cell-ld and paging zone, can encourage more rapid identification. Some optimization may be required in the mobile network too, but the idea would be to avoid any changes to the mobile phone itself. This is one area where femtocell vendors will be able to differentiate themselves.

**Effect of femtocell handover for the user:**

**Usability** – does this cause a problem or poor service to the customer

For voice calls, the user is typically unaware whether the phone is using 2G or 3G mode. The call quality is unlikely to vary in good reception areas – other factors present a bigger challenge.
Billing – what is the impact on how much the user pays for a call. Charges are based on where the call originated (i.e. inside or outside the femtocell coverage), and continue on the same basis regardless of handover to/from the zone.

Synchronization and localization:

Self-Organization and autonomous operation WiMAX networks require a self-organization at both marco/micro BSs and Femto-APs because of the flat network architecture E.g. handover are directly controlled by the BSs and Femto-Aps

Femto-AP shall be a plug-and-play device that can integrate itself into the network without user intervention

QoS and Security issues:

More sophisticated registration and authentication process and encryption of IP packets are necessary
- Femto-APs utilize local ISP networks, which may be different from the operator’s network
- Collaboration and service level agreement between cellular and ISP operators are required
- Cellular operator has no control over the channel and cannot prioritize voice packets from Femto-Aps
- For guarantying end-t-end QoS

Interference Cases:

- Case I
  - FC is covered by one MC
  - FC is covered by two or more MCs
- Case II
  - FC is covered by another neighboring FC
  - FC is covered by two or more neighboring FCs
**Benefits of Femtocell**

- Better coverage and capacity
  - Due to short transmit-receive distance
    - Lower transmit power
    - Prolong handset life
    - Higher SINR
- Higher spectral efficiency
- BS can provide better reception for mobile users
  - Traffic originating indoors can be absorbed into femtocell networks over IP
  - Cost Benefit
    - $60,000/year/macrocell vs. $200/year/femtocell
    - Reduced subscriber turnover
- Enhanced home coverage will reduce motivation for users to switch carriers

**Capacity benefits of femtocell:**

- Reduced distance between sender and receiver leads to higher signal strength [capacity improvement]
- Lowered transmit power decrease the interference for neighboring cells [capacity improvement]
Benefits for end-users:

- Excellent network coverage when there is no existing signal or poor coverage.
- Higher capacity, which is important if the end-user uses data services on his/her mobile phone.
- Depending on the pricing policy of the MNO, special tariffs at home can be applied for calls placed under femtocell coverage.
- For enterprise users, having femtos instead of DECT or Wi-Fi dual mode phones enables them to have a single phone, so a single contact list etc.

Femtocell Benefits to End Users

- Reduced “in home” call charges
- Improved indoor coverage
- Continued use of current handset
- Reduced battery drain
- One consolidated bill
- Multiple users/lines
- Landline support

Femtocell Benefits to Mobile Operators

- Improves coverage
- Reduces backhaul traffic
- Provides capacity enhancements
- Reduces churn
- Enables triple play
- Addresses the VoIP threat
- Stimulates 3G usage
- Captures termination fees
- Allows for multiple users/lines
- Addresses the fixed mobile convergence market with a highly attractive and efficient solution
**Advantages**

- A Femtocell is used for compensating poor cellular coverage inside the homes – in some places.
- A Femtocell can also give lower call charges while the caller calling from home, using the Femtocell as it directly connects to the core network through the internet.
- Some vendors are also planning to incorporate all the three features – Wi-Fi, cellular and DSL into the same box to achieve maximum functionality.
- The voice calls/data calls through the Femtocells are encrypted and the cell phones automatically switches over to the Femtocells when they come in their range – eg. in homes, where they are installed.
- Femtocell units can handle up to three or four simultaneous calls, from the same operator, depending on the model. They can operate with normal cellphones, without any enhancements.
- Femtocell units can help related cellular services like 3G by offering a better speed and data rate when inside buildings, where the coverage and data rate is generally lesser than outside.
- Generally, the cell towers are back-hauled by using lines with bandwidth of around 2 Mbps (in some places) and hence when newer services like 3G are introduced, these lines may not be sufficient and hence may require a upgrade. But with Femtocells, since the subscribers internet connection is used, there may not be an issue with existing infrastructure if Femtocells are adopted in a large scale.
- Femtocells can not only extend the cellular macro network but can also become the primary network if enough Femtocells are adopted in an area. So, all future upgrades etc. can be done by the Femtocells itself, reducing the number of macro base stations required to cover an area – but this is a long shot, based on the current situation and the problems described below.
Disadvantages

- Some internet data plans today, charge on the basis of bandwidth used. So, asking the subscriber to pay additional data charges for internet back-end connectivity for the core cellular network may not be easily accepted.
- Femtocells can support both open and closed usage. That is neighbouring subscribers may or may not be allowed to connect to them. If they are, then the access control list needs to be managed by the cellular network. There will also be a question on the ownership and the location of placement, in case of shared ownerships. If they are not, then the individual subscriber may have to pay the full price (if they are not subsidised by the vendor or operator) for the femtocells.
- If the Femtocells are used to their full capacity, it may require around 500 Kbps – which is available in broadband networks – but not for all plans. Similarly, there might be reduction in call quality/internet browsing if huge files are being downloaded from the internet simultaneously.
- The determination of location of the Femtocells becomes critical as the RF channel in which they need to transmit would be determined by their location and the RF channels used by nearby Femtocells. But normally, a particular operator may have licenses for different channels in adjacent geographic areas so there should not be any overlapping which would result in reduction of quality of communications. Also, they should not interfere with the RF channel used by the overlapping macro cell network. For all these things, the determination of accurate location is very important – and it is not clear as to how the operators are planning to address this.
- At least initially, the Femtocells would work for only a particular cellular operator. So, every one at home may require to change to the same operator.
- Not all cellular operators are on IP Multimedia Subsystem (IMS), which might become the interface for the Femtocells.
- Cellular only service providers are dependant on the broadband services which are beyond their control. So, trouble shooting may become an issue.
**Security**

**Femtocell security risks**

There are a number of concerns that exist about femtocell security. By categorising these femtocell security concerns it is possible to address them and ensure that any risks are minimised.

- **User privacy:** Since a variety of data about the user, including the voice calls and data themselves pass over the Internet. As a result it is necessary to provide security for these IP communications and prevent any monitoring of the data.

- **Denial of service and general service availability:** A significant area of concern for service providers in terms of their femtocell security strategy arises from the fact that the link between the femtocell and the cellular core network is across the Internet and it is IP based. Accordingly the service provider is open to denial of service attacks which overload the network and degrade the service or even totally prevent legitimate users accessing the cellular network.

- **Fraud and service theft:** This form of femtocell security addresses the scenarios where unauthorised users connect to the femtocell and use it in an unauthorised fashion. This may be done to avoid being charged for calls, or to transfer the costs of the calls to the authorised femtocell user. This would clearly give significant adverse publicity which would not be wanted by the operator.

It is therefore essential, that from the first deployment phase for femtocells, to the maintenance phases, operators keep sufficient security measures in place and upgrade them to counter any new techniques that are developed.

**Femtocell security vulnerabilities**

There are a number of areas where there are possible security risks within the overall femtocell system.

It is assumed that the cellular core network is safe from attack. This is a safe assumption as the core network is under the control of the operator, and any security issues would need to be maintained whether femtocells were active or not. Accordingly this area of femtocell security is not addressed.

The main areas of femtocell security vulnerabilities are given below:

- **Wireless link into the femtocell:** Here there is a possible for external wireless transmissions to gain access to the femtocell.

- **The femtocell itself:** It is possible that hackers could gain access into the femtocell and control it for their own use.

- **Internet link:** This is the backhaul link used between the femtocell and the femtocell gateway into the service provider's core network.
Femtocell security measures

In order to prevent femtocell security attacks from succeeding, there are several areas that can be addressed:

- **Use of IPsec:** In order to ensure that the femtocell security is maintained across the Internet IPsec or IP security is used. The IPsec standard is a widely used standard defined by the Internet Engineering Task Force (IETF).

- **Femtocell Secure Authentication:** Authentication is required by both the service provider or operator to ensure that valid femtocells are connecting to the core network. Additionally femtocells need to be correctly identified within the network. Femtocell security procedures using SIM cards authentication or X.509 are used.

- **Wireless link security:** The wireless link is an area where femtocell security is needed to ensure that unauthorised users do not connect or take over the femtocell. Techniques include ensuring that the femtocell coverage area does not exceed the physical area where the femtocell is to be used.

- **EAP, Extensible Authentication Protocol:** This form of protocol is used in a number of wireless networks and its use has been proposed for providing femtocell security.
WiFi vs. FAP

Home routing’ my cell phone

- Goal: To get full network coverage at home

Option 1: Bring the phone to the network

If your cell phone is equipped with Wi-Fi capabilities, you can connect to your Wi-Fi router at home and use a VoIP provider to route your calls. There are several cell phone models already on the market that fit this criteria. They are sometimes called “dual-mode” phones — horrible name. This approach is also sometimes called “VoWi-Fi” or even “VoFi”, short for “voice-over-WiFi”. The iPhone has WiFi capabilities, so it could theoretically make calls over that channel, but Apple didn’t include that functionality out of the box (probably because it would be counter to the interests of AT&T, their carrier partner). But, you can make calls over WiFi using an iPhone by installing software from Truphone.

Option 2: Bring the network to the phone

This is where “femtocells” come in. The idea is to put a mini cell tower in your home. Last week, Motorola announced that it has started trials of femtocells with an unidentified major European operator. (Rumors say that it is Orange.)
Some Factors of Femtocell v/s Wifi
Future of Femtocell

Operators view

- By 2012, there will be 36 million shipments with an installed base of 70 million femtocell serving 150 million users.

![Figure 1: Global Femto Base Station Infrastructure Equipment Market Forecast (Revenue in Millions of U.S. Dollars)](image)

Usage
TOTAL 3G FEMTOCELL DEPLOYMENT
2012: $4.9 Billion

- N America: 21%
- China: 13%
- Japan: 11%
- SEA Asia: 7%
- S. Korea: 6%
- L America: 3%
- E Europe: 3%
- W Europe: 31%
- Africa/M.E.: 14%
- Oceania: 2%
- India: 2%

Femto Forum

26 operators covering 630 million subscribers
Femtocell Vendor’s

44 providers of femtocell technology

Some Femtocells

Ubiquisys

ip.access

Ericsson

Airvana

Radioframe

Samsung
Conclusion

- Femtocells are on a road to nowhere.
- Unsatisfactory coverage and the increasing number of high-data-rate application are two driving forces for femtocell development.
- Potential to provide high quality network access.
- Provide huge capacity gain.
- Not likely to be an immediate and outright success.
- Number of hardware evolutions will probably be needed before form factor, usability and quality of service are adequate.
- Can take a couple of years.
- Therefore, the major immediate benefit is improving in-house coverage especially in rural regions, since 2G and 3G coverage and capacity for urban users is usually sufficient for in-house coverage.