Study Report on Regulatory Issues in Femtocell (Indoor) Deployment Strategy

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INTRODUCTION

Demand for high speed, innovative and up-to-date technologies is always on the rise. Every passing day promises a new possibility and opportunity for the consumers to have access to high quality, highly efficient yet effective and real time services and applications, at the comfort of their homes, workplaces or on the move. With the developments in wireless and fixed line technologies in recent times, we have seen a shift from legacy computers to personal tabs and Smartphones, which are more than just phones. Web browsing, email, messaging, video sharing, networking, location based services, etc are just a few names from this wide range of gadgets which we see every day.

All such services and obviously future services are bandwidth hungry and wireless is the preferred choice for users, we want higher data rates, lower spectrum usage, a lot of applications and at the same time at a cheaper rate, to handle all this, without a liberal wireless spectrum and strong radio engineering, these ambitions cannot be fully realized or implemented.[1]

The world has now moved to or is planning to shift to high end mobile technologies such as 3G, 4G, LTE and most of the developed economies have deployed a good functional fixed broadband network across the board. The case of Pakistan is a little different, 3G cellular services are expected to be started in 2013, whereas the spectrum is limited as always the case. Our users are yet to see a full fledged broadband experience. Efficiency and speed is an important factor for all technologies, whereas the operators will look for solutions which incur lesser CAPEX/OPEX and give a better return on investment, while the regulator will be more than satisfied if both the user and service providers are contented.

[1] The Current Market and Future of Femtocells, by Daniel Lampie Rochester Institute of Technology, Nov 2010

Recent studies have shown that mobile and internet use is higher at homes and offices than in travel. In view of the latest smart operators' strategies, one way to achieve higher data rates, better spectral efficiency and access to high end applications for both home/office users is by deploying "Femtocells", this can further reduce the need for external network construction and would also give operators a fixed-broadband backhaul network with a lower operating cost than mobile and microcell/BTS traffic offloading can be achieved to a better extent. Femtocells are low-powered access points, based on mobile technology operating in the licensed bands, providing wireless voice and broadband services to customers in the home fully up to their expectations.

This study paper will highlight some of the features of femtocells, its benefits, world trends in deployment and a discussion on some regulatory issues in the deployment of femtocells in Pakistani scenario.

Regulatory implication, permissibility of using spectrum, spectrum issues and possible regulatory limitations are discussed in this paper. In addition to this, feedback/input from operators will also be of value for setting up future plans in the development of wireless technologies and services in Pakistan.

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Definitions/Abbreviations

1.	CN:	Core Network
2.	MSC:	Mobile Switching Center
3.	Femtocell:	3GPP: Home NodeB(HNB), 3GPP2: Femto Access Point (FAP)
4.	Handest:	3GPP : User Equipment(UE), 3GPP2:Mobile Station/Access terminal
5.	Femto GW:	3GPP: HNBGW, 3GPP2:Femto Gateway(FGW)
6.	RNC:	3GPP: Radio Network Controller, 3GPP2: Base Station Controller (BSC)
7.	FAP:	Femto access point

1: FIXED MOBILE CONVERGENCE

1.1 Over time, the telecommunication sector has seen various abrupt and continued changes. Most of the enhancements, choice of new services and operators' existence is directly proportional to the ever changing market dynamics and customer expectations. That is one of the reasons that just in over the last two decades we have seen major changes in the whole ICT sector. Simply put, we had desktop PCs and dial-up internet connections as a luxury, and just in a matter of few years we have shifted to high speed internet and smart phones. This change in recent times can be seen as the fastest change as compared with the era before the 80's.

The user is now more inclined to have a terminal which has all the features, e.g. voice, data, video, entertainment, education etc instead having different devices for different services. This has lead to the convergence of technologies and services both. In terms of convergence, we have also seen a shift towards common platform for fixed and wireless technologies and services.

1.2 Fixed-mobile convergence (FMC) is now known as a standard term to define above aspect. Although there are many definitions for this term, some of the most common definitions are given as under:-

i. FMC, is the trend towards seamless connectivity between fixed and wireless telecommunications networks which allows cellular telephone sets to function smoothly with the fixed network infrastructure.[2]

ii. The ultimate goal of FMC is to optimize transmission of all data, voice and video communications to and among end users, no matter what their locations or devices. In the more immediate future, FMC means that a single device can connect through and be switched between wired and wireless networks.

iii. **ITU** has defined FMC as[3] **"**In a given network configuration, the capabilities that provide services and application to the end user defined in Recommendation ITU-T Y.2091 regardless of the fixed or mobile access technologies being used and independent of the user's location. In the NGN environment (ITU-T Y.2011), it means to provide NGN services to end users regardless of the fixed or mobile access technologies being used.

[2] http://searchmobilecomputing.techtarget.com/definition/fixed-mobile-convergence
[3] http://www.itu.int/rec/dologin_pub.asp?lang=e&id=T-REC-Y.2808-200906-I!!PDF-E&type=items

iv. The ITU has also formulated generic requirements for fixed wireless access systems as follows:-[4]

a) Capable of supporting wireline like service.

b) Capable of delivering performance equivalent to cellular voice quality.

c) Capable of delivering fallback rate support for modem and fax service.

d) Optional limited mobility support.

e) Extension of existing cellular standards which may provide a higher level of wireline transparency.

v. FMC, as per ITU-T recommendation Q.1761 with respect to IMT, is "Mechanism by which a user can have basic voice as well as other services through a fixed network as per his subscription options, capability of the access technology." [5]

1.3 Most of the developed markets have already moved towards converged services arena, while the developing world is also seeing the same, however with slower pace. Even then, when we take Pakistani market in consideration, we are noticing a trend of wireless broadband proliferation in Pakistan. This model may also provide a benefit to the declining fixed local loop operators to offer backhaul services together with the wireless operators which will contribute to the development of common FMC infrastructure and will provide a good chance for their survival. In addition to this, both Wireless and fixed line operators can save on their OPEX/CAPEX. [6]

1.4 FMC for the mobile operators is a significant opportunity for subscriber retention and new service offerings over the same platform with minimal changes to their core networks. With the introduction of new cellular technologies such as 3G/4G/LTE, the major concern will be on the delivery mechanism of high speed services for consumers. Customer expectation will be higher and so the cost of delivery. In such situation, FMC can be of significance as it can help the mobile operators to focus more on high quality services with more traffic offloading options from their main radio access network and will not have to worry about backhaul.

1.5 One of the present time smart operator's strategies is that of more coverage, higher speeds and better QoS in residential or office areas where such parameters are significantly compromised. To cater for this problem, one possible solution is to deploy femtocells. This can result in significant cost savings, better radio network coverage and enhanced user experience. The next chapters will discuss about femtocell technologies, it's applications and regulatory implications.

[4] http://www.itu.int/dms_pubrec/itu-r/rec/f/R-REC-F.1490-1-200709-I!!PDF-E.pdf

[5] Draft study paper on Merger of 14 LL and One LDI license, www.pta.gov.pk

[6] Since FMC is a broader term and can be interrelated with many transforming ideas in the ICT, this paper will try to keep FMC limited to mobile services only.

2: INTRODUCTION TO FEMTOCELLS

Background:

"Femtocell", also called as access point base station, is a subminiature base station that is used in indoor environments such as home or office[7]. The connectivity of femotocells with the core network of cellular operator is achieved through subscribers DSL/Internet connection. Such arrangement scenario is not new, as we have already witnessed technologies such as UMA (Unlicensed Mobile Access). By using such technologies, the cellular operators aim to reduce CAPEX/OPEX of its radio access network (RAN), offload traffic from Macrocell network in peak hours and achieve better indoor coverage. However the basic difference between Femtocells and UMA or any other technologies is that Femtocells works in the licensed frequency spectrum allocated to the mobile operators and the users do not have to have any special mobile handsets. Another important feature of femtocells is that they are self optimizing and self configured and do not need any special arrangements from the consumer end. This chapter will highlight important features of the femtocells and its applications.

2.1 What is a Femtocell?

Femtocell is one of the type of small cells. Small cell forum (formerly femto forum) has defined small cells as "Small cells are low-power wireless access points that operate in licensed spectrum, are operator-managed and feature edge-based intelligence. They provide improved cellular coverage, capacity and applications for homes and enterprises as well as metropolitan and rural public spaces. They include technologies variously described as femtocells, picocells, microcells and metrocells."[8]

There are various other definitions of Femtocells known till date and expressed differently by various organizations. However, generally a femtocell is a low-power access point, based on mobile technology, providing wireless voice and broadband services to customers in the home or office environment. Simply put, femtocells are low power mini base stations at homes and offices which operate in the licensed band and are different from WiFi/hotspots etc. As shown in Figure 1.1 below, the femtocell connects to the mobile operator's network via a standard consumer broadband connection, including ADSL, cable or fiber. Data to and from the femtocell

[7] FMC Handbook by Syed A.Ahson, Mohammad Ilyas, 2011, Femtocell networks, chapter 3
[8] http://www.smallcellforum.org/Files/File/SCF-Small_Cells_White_Paper.pdf

is carried over the Internet – or at least, over an Internet-technology network provided by an Internet service provider (ISP).

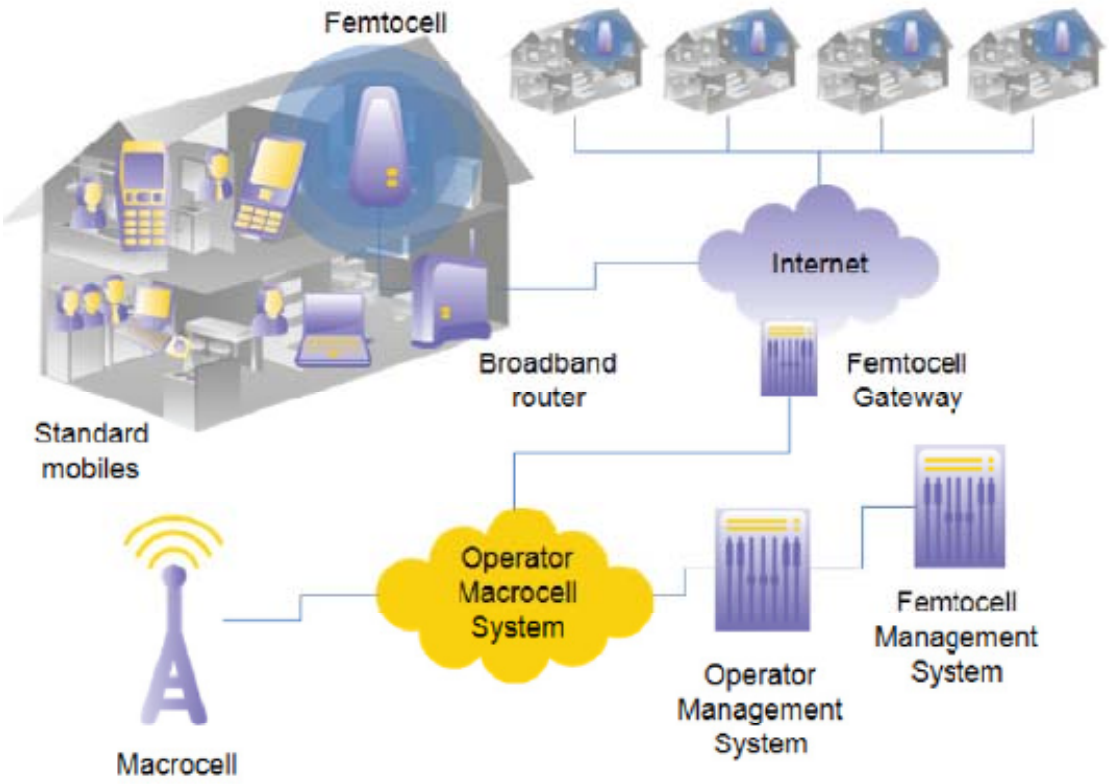

Figure 2.1- Typical Femtocell Deployment Scenario[9]

Femtocells are short-ranged (10-30 m) low powered (10-100 mW) access points which provide mobile coverage and capacity over internet-grade backhaul. Customer's broadband Digital Subscriber Line (DSL) or cable or fiber to the home (FTTH) broadband Internet connections are used for backhaul to the operator's core network. Femtocells are lower in cost than typical macrocells while retaining full operator management even if they are located at the customer premises.

[9] Regulatory Aspects of Femtocells – 2nd Edition, Published by Femto Forum, March 2011

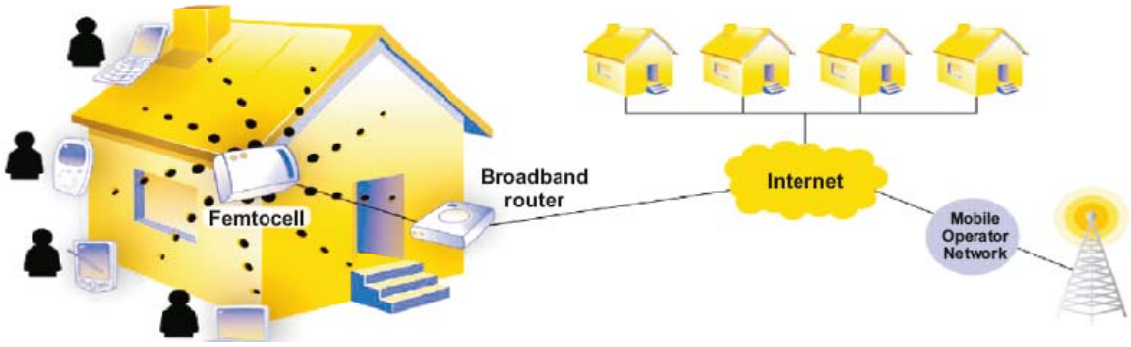

Figure 2.2:Basic Femtocell Topology [10]

Femtocells are different from macrocells, microcells, picocells and relays in terms of power, backhaul and access modes as mentioned below[11]:

- **Macrocells** are conventional base stations with power about 20W, that use dedicated backhaul, are open to public access and range is about 1 km to 20 km.
- **Microcells** are base stations with power between 1 to 5W, that use dedicated backhaul , are open to public access and range is about 500 m to 2 km.
- **Picocells** are low power base stations with power ranges from 50 mW to 1 W, that use dedicated backhaul connections, open to public access and range is about is about 200 m or less .
- **Femtocells** are consumer-deployable base stations that utilize consumer's broadband connection as backhaul , may have restricted association and power is less than 100 mW .
- **Relays** are base stations using the same spectrum as backhaul and access and has similar power as Picocell.

2.2 Terminologies

Femto Forum uses Femtocell Access Point (FAP) terminology for the femtocell base station while 3GPP uses Home Node B (HNB) for 3G femtocell and Home eNodeB (HeNB) for LTE Femtocell. Several FAPs are connected to the FAP Gateway (FGW) or H(e)NB Gateway which is a mobile

[10] Technology Digest on LTE Femto Access Points, Issue 7, Jan 2012, TRAI India
[11] 10

operator's equipment (usually physically located on mobile operator premises) through which the FAP gets access to mobile operator's core network.

Working: Typically, a single femtocell can deliver voice services simultaneously to at least four users within the home, while allowing many more to be connected or 'attached' to the cell. Femtocells can deliver data services to multiple users, typically at the full peak rate supported by the relevant air interface technology, currently several megabits per second and rising to tens and hundreds of megabits per second in the future. Data from multiple femtocells are concentrated together in a gateway, managed by the mobile operator, and ultimately find their way back to the operator core network along with the data from the conventional operator macrocell network. The operator core network also contains a management system which provides services to the femtocell, ensuring that the services experienced by the user are secure, of high quality and can coexist with the signals from other femtocells and the outdoor network. In practice, the femtocell may be either a stand-alone device, which connects into the customer's existing broadband router, or may form a key component of a home gateway device which incorporates the router and other technologies, such as a broadband modem, Internet router and Wi-Fi access point into a single integrated device. Examples of both types are illustrated in Figure 1.4. Note that femtocells are consumer devices, intended to be suitable Introduction to Femtocells.

The primary objective of any Femtocell Access Point (AP) deployment strategy is to extend the same quality voice service that subscribers currently receive from the macro network, down to the home or workplace. A successful deployment will improve coverage, reduce macro network capital expenditure (CAPEX) and result in increased cellular operator visibility in the home.

2.3 Attributes

The Femto Forum has created the following set of attributes, *all* of which are necessary for a device to qualify as a femtocell:

1. **Uses mobile technology**. Femtocells use fully standard wireless protocols over the air to communicate with standard mobile devices, including mobile phones and a wide range of other mobile-enabled devices. Qualifying standard protocols include GSM, WCDMA, LTE, Mobile WiMAX, CDMA and other current and future protocols standardized by 3GPP, 3GPP2 and the IEEE/WiMAX Forum, which collectively comprise the technologies included in the ITU-R

definition of IMT.1 The use of such protocols allows femtocells to provide services to several billion existing mobile devices worldwide and to provide services that users can access from almost any location as part of a wide-area network.

2. **Operates in licensed spectrum**. By operating in spectrum licensed to the service provider, femtocells allow operators to provide assured quality of service to customers over the air, free from harmful interference but making efficient use of their spectrum.
3. **Generates coverage and capacity.** As well as improving coverage within the home, femtocells also create extra network capacity, serving a greater number of users with high data-rate services. They differ in this from simple repeaters or 'boosters' which may only enhance the coverage.
4. **Over Internet-grade backhaul**. Femtocells backhaul their data over Internet-grade broadband connections, including DSL and cable, using standard Internet protocols. This may be over a specific Internet service provider's network, over the Internet itself or over a dedicated link.
5. **Permits low prices.** The large volumes envisaged for femtocells will allow substantial economies of scale, driving efficiencies in manufacturing and distribution in a manner similar to the consumer electronics industry and with pricing projected to be comparable with access points for other wireless technologies.
6. **Fully managed by licensed operators.** Femtocells only operate within parameters set by the licensed operator. While they have a high degree of intelligence to automatically ensure that they operate at power levels and frequencies that are unlikely to create interference, the limits on these parameters are always set by operators, not by the end user. The operator is always able to create or deny service to individual femtocells or users. This control is maintained whether the femtocell itself is owned by the operator or the end user.
7. **Self-organizing and self-managing.** Femtocells can be installed by the end customer. They set themselves up to operate with high performance according to the local and network-wide International Mobile Telecommunications, comprising IMT-2000 (usually known as 3G) and IMT-Advanced (which may become known as 4G).

2.4 Standards

Most air interfaces included in the global ITU-R IMT family have active programs to develop standards for femtocells. These include:

- 3GPP standards for Home Node-B, which is a WCDMA femtocell. Both FDD and TDD options are likely and a TD-SCDMA variant is also planned.
- 3GPP standards for Home eNode-B, which is an LTE femtocell. Both FDD and TDD options are envisaged.
- 3GPP2's program for femtocells for cdma2000, cdma2000 1x, HRPD, 1x EV-DO and UMB.
- WiMAX Forum's program for WiMAX femtocells based on IEEE standards.

In all cases femtocell standards support deployments in all of the existing licensed spectrum bands in which macrocells operate.

2.5 Types

Individual femtocells are generally available in various hardware types. Although individual standards differ in their definitions, the following broad classes can be identified, though these are not exclusive or prescriptive:

- **Class 1 (***Best known***)**. Femtocells in this class deliver a similar transmit power and deployment view to Wi-Fi access points (e.g. typically 20 dBm of radiated power2 or less) for residential or enterprise application. They will each deliver typically 4–8 simultaneous voice channels plus data services, supporting closed or open access. Installed by the end-user.
- **Class 2.** (typically up to 24 dBm of radiated power), possibly to support longer range or more users (say 8–16). Supports closed or open access. May be installed by the end-user or the operator. May be viewed as an evolution of picocell technology.
- **Class 3.** Higher power (as for Class 2) for longer range or more users (e.g. 16 or greater). Typically carrier deployed and may well be open access. Could be deployed indoors (e.g. in public buildings) for localized capacity, outdoors in built-up areas to deliver distributed capacity or in rural areas for specific coverage needs.

2.6 Applications

Femtocells started as a means of delivering services to residential environments. This remains a core application for femtocells and it enables femtocell technology to be produced in large Effective Isotropic Radiated Power – EIRP. Femtocells: Opportunities and Challenges for Business and Technology volumes and low costs. However, femtocells are not limited to this application and early deployments for other purposes are anticipated. Current applications include:

- **Residential** – Femtocells are installed indoors within the home by the end user and may be stand-alone devices or integrated with other technology such as residential gateways. Access to the residential femtocell will often be closed – restricted to a specified group of users – but may also be open to all registered users in some cases. Typically these application needs will be met using class 1 femtocells.

- **Enterprise –** Enterprise femtocell deployments may be in small-office, home-office situations, in branch offices or in large enterprise buildings. Femtocells for this purpose are usually of class 1 or class 2 and will typically support additional functionality compared with residential devices such as handover between femtocells, integration with PBX and local call routing. Will primarily be used indoors, but could also be used to serve a corporate campus. Installation will probably be managed by the carrier, but may be achieved by the enterprise itself or its IT subcontractors. Access may be closed or open.
- **Operator –** This class encompasses a wide variety of applications where operators use femtocells to solve specific coverage, capacity or service issues in both indoor and outdoor environments. These could be composed of class 1, 2 or 3 devices and will usually be open access. They will be installed by the operator or by third parties under the operator's direction.
- **Others –** These application classes are not exclusive and it is expected that other innovative ideas for the application of femtocells will emerge, for example on aircraft, trains or passenger ferries. In all cases the essential attributes of femtocells described earlier will be observed, enabling full compliance with relevant local customer, operator and regulatory requirements.

2.7 Network Architecture[12]

For consideration under this study paper, we will have a look at the two main architectures for femtocells defined by 3GPP and 3GPP2, as under:-

3GPP Femtocell Network Architecture

Below figure illustrates 3GPP femtocell architecture. More details about this architecture can be found in standard document: 3GPP TS 25.467, UTRAN architecture for 3G Home NodeB document of 3GPP.

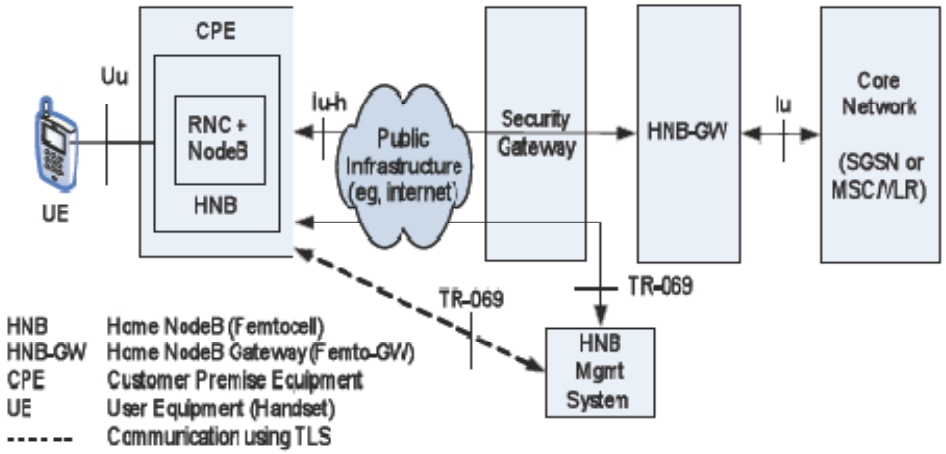

Figure: 2.3: 3GPP Femto Architecture

- *HNB* supports NodeB and RNC-like functions. It connects to the handsets (UEs) via existing Uu interface and to the HNB-GW via new Iu-h interface. It is typically owned by the end user.

[12] QUALCOMM Research paper - **Femtocells – Architecture & Network Aspects,** *Jen Chen, Peter Rauber, Damanjit Singh, Chandru Sundarraman, Peerapol Tinnakornsrisuphap, Mehmet Yavuz* , 28-1-2010

- *HNB-GW* concentrates HNB connections (many-to-one relationship between HNBs and HNB-GW) and presents itself as a single RNC to the core network (CN) using the existing Iu interface. This allows for scaling to large numbers of HNBs, and avoids new interfaces and HNB-specific functions at the CN.
- *Home Management System (HMS)* is used for provisioning HNB configuration data remotely using the TR-069 family of standards. TR-069 is traditionally used for DSL modem configuration
- *Security Gateway (SeGW)* uses IPSec [2] to provide a secure link between the HNB and the HNB-GW (over Iu-h) and between the HNB and the HMS. These links can either use the same or different SeGWs. The SeGW is also responsible for HNB authentication.

3GPP2 Femtocell Network Architecture

This section describes two architectures for femto systems as specified by 3GPP2. (Circuit Switched and Packet Switched, for Voice and Data respectively). Detailed descriptions for both architectures can be found in 3GPP2 standard X.S0059-0, *Femto Network Specifications*, Feb 2010

Circuit-Switched Voice Femto System Architecture

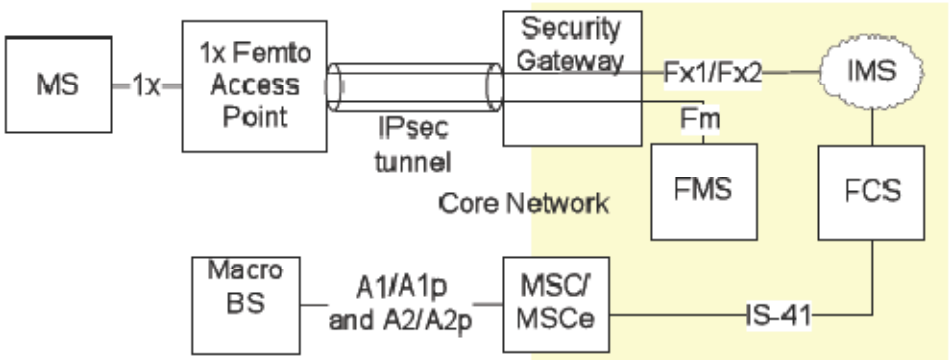

Figure 2.4: CDMA2000 Circuit Switched Voice Femto Architecture

The above figure shows the architecture for supporting circuit-switched (CS) voice service via a femtocell.

- *Femto access point (FAP)* has equivalent functions to a Base Station (BS) in the macro network, e.g., communicating with the handset (MS) and setting up a voice circuit with the CN.
- *Femto Convergence Server (FCS)* provides equivalent functions to an MSC in the macro network, e.g., providing processing and control for calls and services. However, 1x CS FAP and FCS do not communicate using the legacy BS-MSC interface. Instead, Fx1 and Fx2 interfaces which are based on the IP Multimedia Subsystem (IMS) framework are used. From the perspective of a macro MSC, the FCS appears as another MSC and supports the IS-41 interface for inter-MSC communication.
- *Femto Management System (FMS)* is used for remotely configuring the FAP via the Fm interface. Like in the 3GPP architecture, this OA&M interface is based on TR-069.
- *Security Gateway (SeGW)* provides secure communication between the FAP and the operator's core network. IP packets between FAP and CN are encapsulated in an IPSec tunnel. As a security gateway the FGW is also responsible for authenticating and authorizing the FAP.

Packet Data Femto System Architecture

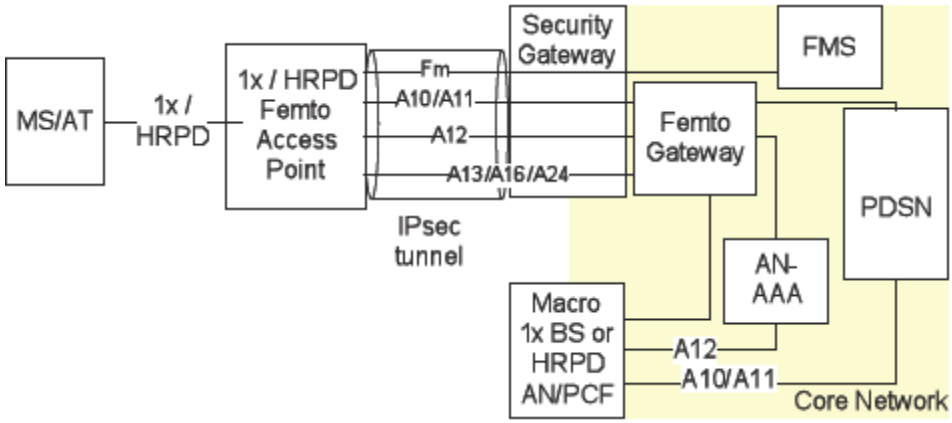

Figure 2.5:CDMA2000 & HRPD Packet Data Demto Architecture

- Above figure shows the 3GPP2 architecture supporting packet data services through either 1x or HRPD (also known as EV-DO) air interfaces. In case the FAP supports both 1x CS and 1x/HRPD packet data, common entities (i.e., FGW and FMS) and interfaces (i.e., IPSec tunnel and Fm interface) will be used.
- *FAP* provides functions equivalent to an HRPD access network (AN) or a 1x BS.
- *Femto Gateway (FGW)* provides proxy function support for HRPD AN interfaces such as A11, A12, A13, A16, and A24 interfaces. This allows the FAP to transfer an air-interface session to and from the macro AN in both idle and active states for seamless handoff. It also supports paging of an AT from the macro AN to the FAP. The use of FGW is optional in the standard.
- *PDSN* routes MS/AT originated or MS/AT terminated packet data traffic and establishes, maintains, and terminates link layer sessions to ATs. For seamless IP mobility, the FAP should connect to the same PDSN as the macro AN or BS in the area. Since the FAP reuses A10/A11 interfaces which are identical to interfaces used by a macro AN/BS, the FAP appears as just another AN/BS from the perspective of the PDSN.
- *AN-AAA (AN Authentication, Authorization and Accounting) server* is responsible for authenticating and authorizing ATs via A12 interface for both macro AN and FAP.

Complete* QUALCOMM Research paper - Femtocells – Architecture & Network Aspects, *can be downloaded at:-
http://www.qualcomm.com/media/documents/files/femtocells-architecture-network-aspects.pdf

3: DEPLOYMENT STATUS OF FEMTOCELLS

3.1 Market Status

"In June 2011, Informa Telecoms Media estimated that there were in excess of 2.3 million femtocells active both privately in homes and offices, as well as publically in metropolitan and rural environments. As such, there are more 3G femtocells than conventional 3G base stations globally and Informa forecasts growth to continue with 48 million access points in use globally by 2014."[13]

As per the recent report of "Small Cell Forum" [14], so far 66 mobile operators have joined the forum which represents 2.99 billion mobile subscribers worldwide, across multiple wireless technologies (WiMAX, UMTS and CDMA) and accounts for 47% of total mobile subscribers worldwide plus 76 vendors, illustrating that the femtocell ecosystem is experiencing healthy growth. [15].

In addition to above, according to Informa Telecoms & Media's forecasts, the number of small cells deployed will overtake total macro cells during year end 2012. Informa also expects 91 million small cells in the market during end-2016, whereas the CDMA femtocell market is also growing with Verizon Wireless and Sprint having launched enterprise femtocells during year end 2011. It is worth mentioning here, that as of December 2012, Sprint's deployment reached 1 million units as of October 2012.[16]

The small-cell market has been active since 2007, when Sprint launched consumer femtocell services to improve its customers' experience. Since then, several operators have pioneered new services and in new market segments and accelerating the evolution of the small-cell market (see below figures).

First launch	Sprint Wireless (US)	September 2007
First enterprise launch	Verizon Wireless (US)	January 2009
First public safety launch	TOT (Thailand)	March 2011
First standardized launch	Mosaic (US)	February 2012
First LTE femtocell	SK Telecom (South Korea)	June 2012
Source: Informa Telecoms & Media		

Figure 3.1: Small Cell Industry Firsts

[13] http://www.cellular-news.com/story/52251.php
[14] http://smallcellforum.org/smallcellforum/resources-white-papers http://smallcellforum.org/smallcellforum_resources/pdfsend01.php?file=Small_Cells_2012Q2_Market_Update.pdf
[15] http://smallcellforum.org/smallcellforum/resources-white-papers http://smallcellforum.org/smallcellforum_resources/pdfsend01.php?file=Small_Cells_2012Q2_Market_Update.pdf
[16] Small cell forum, issue Dec 2012 available on http://smallcellforum.org/smallcellforum_resources/

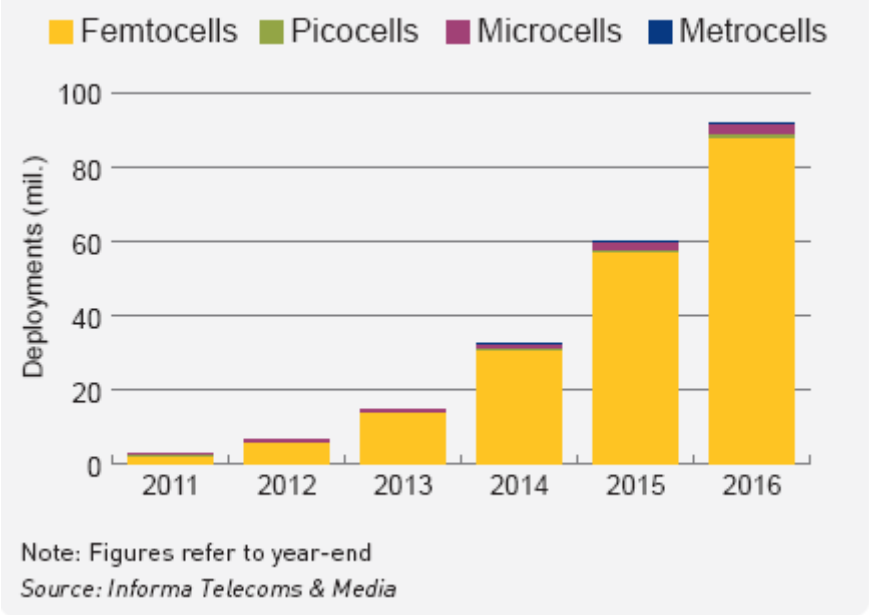

Figure 3.2: Deployment Projection

3.1.1 Cost

Recent surveys show that the price of a standard femtocell device has dropped significantly to around $100 [17]. To an extent that for its initial soft launch, AT&T chose a one-off purchase price for the femtocell of $149.99, but by offering a $49.99 rebate for customers who also used AT&T broadband, and a further $100 rebate for cellular customers taking a $19.99 'unlimited voice minutes' femtozone tariff, the company effectively made it possible to acquire a femtocell free of charge.[18]. With the increase in penetration of femotcells, it is expected that the price cap will further fall resulting in cheaper cost for the consumer.

3.2 Case Study – Vodafone Greece[19]

Here we refer to a recent case study by the Small Cell Forum/Informa Telecoms for understanding one of the possible approaches in deployment of Femtocells. Instead of considering any other developed economy's case, the forum has taken Vodafone Greece for understanding basic concept behind femto cells. Vodafone Greece is one of the largest mobile operators in Greece and has recently formed a strategic partnership with Hellas Online (HOL), a fixed-line provider which offers triple-play services. [20]

Vodafone Greece has consistently led with its mobile broadband strategy and is one of just two operators in Greece currently operating and deploying LTE networks in urban areas.

[17] http://www.pcworld.com/article/192855/article.html
[18] www.smallcellforum.org/smallcellforum_resources/pdfsend01.php?file=034_SCF_Case-Study_ATT.pdf
[19] http://smallcellforum.org/smallcellforum_resources/pdfsend01.php?file=Small-Cells_2012Q4_Market-Status-Report.pdf
[20] http://smallcellforum.org/smallcellforum_resources/pdfsend01.php?file=Small-Cells_2012Q4_Market-Status-Report.pdf

Vodafone Greece has chosen small cells as one of many tools to maintain a competitive edge. It started with consumer femtocells and moved to public-area femtozone services, a move that could lead to it generating new revenue. Its innovative project aims to provide for the Greek consumers' growing demand for Internet access by establishing Internet usage and free access as a daily commodity.

Consumer femtocells: Full Signal

Vodafone Greece launched its consumer femtocell service in July 2010, the first of Vodafone's subsidiaries to do so after Vodafone UK. The service, called "Full Signal" (see fig. 3.3), offers a Femtocell Access Point to users who need a good mobile signal in every corner of their house or office – even those in basement flats or buildings with thick walls that can block mobile signals. Vodafone UK is now using a similar branding for its consumer femtocell, changing its name from "Vodafone Access Gateway" to "Sure Signal" to make sure that consumers understand what the service does without the need for more explanation: The service's adverts on national television promote the benefits of the service rather than the technical properties of the access point.

Figure 3.3: Vodafone Greece "Full Signal"

Vodafone Greece's "Full Signal" access point currently retails at €90 (US$117) and is being offered at discounted prices or for free to contract customers wishing to strengthen their indoor coverage.

The femtocell service is the first in the Greek market and the one with the highest installed base. Although Greece may present a somewhat limited potential for such a service – due to a strong prejudice against cellular masts – the Full Signal service is well accepted and significantly improves the customer experience where used.

Public-area small cells: Location-based services

After establishing its consumer femtocell service, Vodafone Greece launched a public-area small-cell service in December 2012 in approximately 200 fast-food restaurants and cafeterias of a well-known retail chain around Greece. Importantly, this is the first hard launch of small-cell zone services based on location, which may enable a variety of new business models while enhancing the user experience.

Vodafone – through its partnership with HOL – has opted to provide both 3G and Wi-Fi access in order to focus on a "free data" value proposition rather than restrict itself to either one of these technologies. Wi-Fi and femtocells allow not only smartphones and Internet feature phones, but also notebook computers and tablets, to be connected to the network.

Service description

The service, named “Free 3G Hotspot”, is deployed in approximately 200 Flocafe cafeterias and Goody’s fastfood restaurants across Greece. By using a small cell and a directional antenna, Vodafone Greece is able to create a new cell that covers the indoor location of these venues, enabling its network to handle traffic generated in these areas differently. The user experience when entering these areas is described below (see also fig. 3.4).

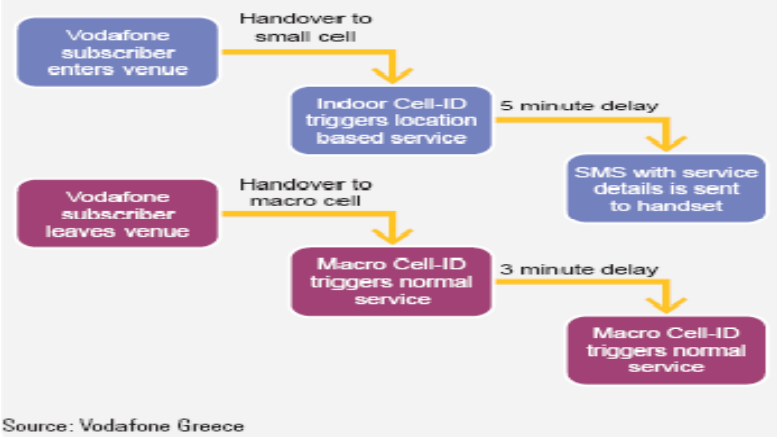

Figure 3.4:
Vodafone Free 3G Hotspot: Internet Service Flow at customer entry & departure from small-cell coverage

As soon as the customer device is “camped” to the small cell, all traffic through the small cell is whitelisted and does not count towards the subscriber’s monthly allowance. An SMS notification is sent after five minutes to alert the user about the service; this delay was implemented to avoid sending the SMS to customers who do not intend to remain in the 3G Free Hotspot coverage area of the restaurant/café. In a similar fashion, an SMS is sent when the user leaves the coverage area of the small cell but with a shorter delay.

Vodafone Greece has also launched an Android app to notify subscribers in real time when they enter or leave a Free 3G Hotspot: The app monitors the ID of the cell that the handset is connected to and notifies the user. The majority of user reviews in Android’s Google Play store are positive, suggesting that users perceive the service in a positive way and understand the benefits of connecting to the small cell. To summarize, Vodafone Greece has launched a zone-based service driven by a small cell as well as an Android app that can be used for value-added services.

Deployment drivers
The deployment drivers for Vodafone’s Free 3G Hotspot are first and foremost aimed at establishing Internet usage and free access as a daily commodity. The competitive and financially-challenging environment in Greece does not allow much flexibility for mobile operators to launch new services but Vodafone Greece has created a relatively cost-effective new location based service that has the potential to attract mass market interest. It is a service that could, in the future, potentially provide new revenue opportunities by offering advertising options to venue owners through Android apps or other location-based services.

The complete report can be downloaded at http://smallcellforum.org/smallcellforum_resources/pdfsend01.php?file=Small-Cells_2012Q4_Market-Status-Report.pdf

4: GLOBAL REGULATORY TRENDS

4.1 Since regulations always lag behind technologies, it is the role of regulators to keep pace with the changing trend in technologies, and to adjust its policies and regulations to accommodate latest and useful technologies with minimal changes to existing network infrastructures and business layouts. During recent times, to address radio spectrum and regulatory issues, some of the developed economies have also taken some measures and decisions to accommodate femtocell developments. This chapter briefly highlights some of the important regulatory developments concerning Femtocell deployments. From these facts, we will see that different regulators have handled this differently, the deployment of femtocells, as according to their own regulatory environment and trend in their countries.

4.2 Worldwide trends

Singapore:

4.2.1 The Singapore Regulatory Authority (IDA-Singapore) has first accommodated deployment of Femtocells by amending their present regulations. Firstly Amendment in Telecom Radio Regulations in 2009, in which the class license for radio was given a new name, "INDIVIDUAL STATION CLASS LICENCE AND STATION (SPECTRUM) CLASS LICENCE" and such licensees are obliged to ensure that the radio-communication station is approved by the Authority before it is used for connection to any telecommunication system or equipment belonging to a public telecommunication licensee. [21]

4.2.2 Similarly, Regulations 23(4) and 65A(1) of the same regulations were also amended and definition of femtocell has been updated to read as "under Radio-communication Station Operated By Telecommunication Licensee, A femtocell with an output power limit that does not exceed 100 mW EIRP and which is connected to a telecommunication licensee's public cellular mobile telephone system or public wireless broadband access system." [2]

UK:

4.2.3 In an OFCOM statement issued in June 2011, definition of femtocell was added its Wireless telegraphy Act, read as "A "femtocell" is a base station of the Network which operates at a power not exceeding 20dBm E.I.R.P. per carrier which may be established by customers of the Network but which is or will be used only by and under the control of the Network, following the establishment of a telecommunications link between the femtocell and the Network".

4.2.4 Conditions for Femtocells: In respect of femtocell equipment and smart/intelligent low power repeater equipment, the conditions relating to the keeping of records for a normal

[21] http://www.ida.gov.sg/doc/ Policies%20and%20Regulation/ Policies_and_Regulation_Level2/ Cap323/TelecomRCAmendtRegs2009.pdf

base station such as postal address, National Grid Reference (to 100 metres resolution) and antenna height and type; were omitted.

4.2.5 In June 2009, Ofcom also provided clarity on its approach to femtocell regulation [6]. It clarified that regulations on provision of emergency call location and national roaming access to emergency calls applied equally to femtocell users as to macrocell users. It also proposed to vary the existing operator 3G licenses to remove the requirement to keep records of the location and technical details of femtocell equipment, recognizing that this may be impractical for a wide deployment of femtocells. This clarity followed previous statements from Ofcom recognizing the potential significance of femtocells, such as:

"they form part of a vanguard of a long-promised technology that has the potential to enable new forms of competition across communications networks: fixed-mobile convergence."

Europe:

4.2.6 In Europe[22], the Radio Spectrum Committee (RSC), in 2008 decided that, in view of the control which operators can exert over femtocells as part of their existing network, femtocells could operate under the existing spectrum licensing regimes of member states and there was no current need for RSC to take action. They also noted that the increased spectrum efficiency available from femtocells was a positive development:

"Noting that femtocells operate as part of the operator's existing network (using the same frequencies) and that the operator remains in control of the femtocell at all times, it is reasonable therefore to assume that femtocells will comply with the existing technical licensing conditions in each specific case."

Japan:

4.2.7 Japanese regulators conducted a series of consultations during 2008[23], and announced the outcome in December 2008. The outcome included a relaxation of a previous requirement for trained personnel to apply power to all classes of base station, enabling femtocells to be installed by end users. For this purpose a particular definition of femtocells was provided, including a specified low output power and requiring that transmissions only occur when connectivity to the operator network is available.

USA:

4.2.8 In October 2009, in a speech at CTIA, Julius Genachowski, Chairman of Federal Communications Commission (FCC) stated: *"Spectrum is the oxygen of our mobile networks. While the short-term outlook for 4G spectrum availability is adequate, the longer-term picture is very different. I believe that the biggest threat to the future of mobile in America is the looming spectrum crisis."* Genachowski proposed that the FCC will look at secondary markets

[22] Femtocell Market Status, Issue no. 1, Nov 2009, Published by the Femto Forum

[23] Femtocell Market Status, Issue no. 1, Nov 2009, Published by the Femto Forum

to add more spectrum and will look to make its spectrum policies more flexible to encourage the use of unlicensed spectrum. He also said the FCC will encourage the use of smart antennas and femtocells.

FCC regulates the amount of radiation which radio transmitters can output. The FCC has a categorical exclusion that allows wireless carriers to skip an in-depth radiation analysis as long as the radiating antenna is above a certain height and under a certain transmit power. Femtocells do not have to meet the same criteria as they use an extremely low transmit power. The electromagnetic radiation emitted from a mobile device when connected to a femtocell is far less than what the mobile emits when connected to a macrocell, possibly providing a safer connection. This allows femtocells to skip many of the regulatory hurdles associated with macrocells.[24]

China:

4.2.9 In September 2009 at the China Femtocell Symposium, Xie Feibo, Director of State Radio Regulatory Committee, MIIT stated: "Femtocells are an excellent technology that combine the technical advantages of wireless and fixline. From my point of view, femtocells should be adopted, and enthusiastically promoted.", while Hou Ziqiang, Commission Member of Telecom and Science Division, MIIT said "Currently we are facing a very serious challenge regarding the dead zone of wireless telecommunications in cities, especially with 3G network indoor service. We note that femtocell technology is very helpful and effective in resolving the weakness of the network signal in cities. From my point of view, the femtocell, as a solution for a home base station, will have a very bright future."[25]

ITU:

4.2.10 In July 2009 the International Telecommunications Union provided a common description of 'Femto Access Nodes', reflecting the current state of the industry and not constraining future developments[26]

4.3 APT Wireless Group (AWG-11)

During the 11th Meeting of the APT Wireless Group (AWG-11), held in Sept 2011, a detailed questionnaire from APT member countries was developed to evaluate the current and future scope of femtocells. In this regard, the group published its findings through its document named AWG-11/OUT-05(Rev.1). It is important to highlight some of the important findings of the report to better assess femtocell applications and deployment in different countries.[27]

This questionnaire report focused on four target groups, which are regulators, operators, vendors, and other institutions. The summary answers of the questionnaires is given at **Annex-A.**

[24] Femtocell Market Status, Issue no. 1, Nov 2009, Published by the Femto Forum
[25] Femtocell Market Status, Issue no. 1, Nov 2009, Published by the Femto Forum
[26] Femtocell Market Status, Issue no. 1, Nov 2009, Published by the Femto Forum
[27] **The 11th Meeting of the APT Wireless Group (AWG-11), AWG-11/OUT-05 (Rev.1),** 17 September 2011

1. **Femtocell deployment and plan**

   Most of the regulators were convinced that Femtocell deployments and planning has been established and almost all vendors already supplying the related solutions to the telecom market. In spite of that, some operators are still under planning or not intend to deploy Femtocell.

2. **Type of Femtocell that are deployed and supported**

   The 3GPP type mostly already in market and supported by regulators and operators.

3. **Spectrum and terminal regulatory that are applied, held and supported**

   Regulators mostly prefer not to allocate the frequency exclusively and using the existing cellular phone services spectrum (Regulators which are answer “Others”). Regulators also regulate the kind of terminal for Femtocell based on their national standard specification. All operators have frequency exclusive allocation; however, in some countries license issue has not been decided yet and some operators have other licenses (comprehensive licence and bucket license).

4. **Interference issue**

   Concerning interference issue, regulators let the operator to manage by themselves and facilitate coordination to solve inter-operator interference. Meanwhile, operators do not use different spectrum to avoid interference issue.

5. **Technical Challenge**

   Most of the operators are convinced that the most technical challenge of deployment Femtocell is QoS management. Meanwhile, vendors convince that the most technical challenge of deployment Femtocell is interference management.

6. **Backhaul type**

   Femtocell backhaul type solutions mostly support fast Ethernet and xDSL. Meanwhile, operators support all kind of backhaul link type (xDSL, FTTx).

7. **Services of Femtocell**

   Data access and application, and location aware based service/application are service drivers to monetize Femtocell deployment.

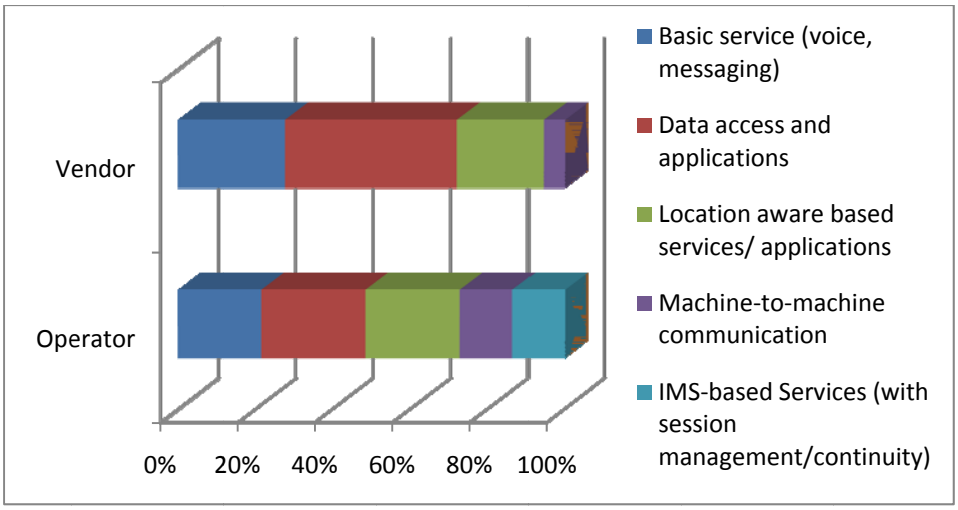

Figure 4.1: Services of Femtocell

8. Licensing issues for femtocell

Among the response to subject query, two regions responded with their views, Singapore & China. Summary of their response is as under:-

Singapore-Alcatel-Lucent:-

Administrations have recognized that adding new spectrum is not enough to address the mobile data traffic demand over the next 5 years. For example in January 2011, the FCC announced: "We need to encourage more innovative and efficient uses of spectrum. We'll continue to encourage dynamic spectrum sharing and secondary markets for spectrum, as well as development and deployment of femtocells, smart antenna technology, and devices that can access unlicensed spectrum like Wi-Fi to off-load traffic from cellular networks." Ref http://www.fcc.gov/Daily_Releases/Daily_Business/2011/db0120/DOC-304191A1.txt

Femtocells are a new form of equipment, where the base station function is formed into Customer Premises Equipment (CPE). Hence local regulatory authorities need to treat there use as consumer equipment rather than a base station as standard telecom equipment. The guiding principles being;

1. Femtocells operate in and should comply with the operators existing spectrum allocation
2. Femtocells should be exempt for individual "base station" type registration since their output power is similar to existing User Equipment (mobile handsets)
3. Femtocells should seek Type Approval for use in a consumer home/office environmen
4. Femtocells should be clasified such that they can be installed by the end-user
5. If neccessary clarification of regulations on the provision of emergency call location and national roaming access to emergency calls applied equally to femtocell users as to macrocell users.

China-(Huawei, Datang, ZTE):-

The main difficulty for femotcell application is interference issue; even though within the industry, there is in-depth discussion about the mitigation methods to be adopted, the interference issue is existed at much extent; provided there is particular license associated to femto, it would be a way out.

Complete AWG Report can be downloaded at http://www.apt.int/sites/default/files/Upload-files/AWG/APT-AWG-REP-21_APT_Survey_Report_Femtocell.doc

5: REGULATORY ISSUES IN PAKISTAN

5.1 While from the previous chapter we observe that different regulatory authorities and operators have handled the strategic deployment of femtocells in different ways which is most suited to their own regulatory and market situations, Pakistani market is a little different. There are three broad policies in place, 1) Mobile Cellular Policy, 2) Broadband Policy and 3) Fixed line deregulation policy. The present regulatory regime encompasses on a split licensing regime, such as LDI, FLL/WLL, Cellular and Value Added Services. As per this setting, separate license for local loop and cellular service exist, however, no converged/unified license is in place which allow any operator to provide both these services. Since femtocells fall under converged services therefore some possible implications in this regard are discussed below.

5.2 Possible Implications of deploying Femtocells:

5.2.1 Use of Broadband for Backhaul:

As a standard feature for deployment of femtocells, broadband connection of the user (whether through standard ADSL or Optical (FTTH) or any other broadband technology), is of utmost importance, as it will be used for backhaul connectivity of femtocells with the cellular operator's core network. Since, in Pakistan the fixed line access falls under the domain of fixed line operators, there can be issues while delivering cellular services through using the fixed line access, such as, ownership of the femtocell devices (user/local access provider/cellular operators), femto access network (fixed line operator or cellular operator). While it is understood that in the certain markets, like US, we take example of AT&T which provides both fixed and mobile services, it is much easier for such operators to provide femtocell based services over their own fixed infrastructure. However, in the case of Pakistan, there can be two options, as under:-

a. The cellular operator can have an interconnection agreement with the broadband provider for delivery of femtocell based services to the end user. The responsibility of broadband will be borne by the fixed line operator whereas other portions of the network by cellular operators. This also means that the broadband connection be of standard and will ensure uninterruptable services to the end user.

b. The cellular operator can provide femto based services through existing DSL/ Broadband connection of the end user without going into any interconnect agreement with the ISP/Broadband service provider, however performance of such services will not be the responsibility of cellular services provider or the ISP provider, however other means to ensure continued service must be thought of.

5.2.2 Present Licensing Regime

The existing regulatory structure of the Pakistani Telecommunication sector is driven by three main policies, namely, (1) De-Regulation Policy for Fixed-Line sector 2003, (2) Mobile Cellular Policy 2003-4, and (3) Broadband Policy. Under the current Telecommunication Act, Rules, Regulations and aforementioned policies, the licensing structure is mainly focused on Service based authorization, e.g. a Local Loop license for local loop services, LDI license for Long Distance & International service etc. Apart from this, there are integrated licenses held by PTCL, NTC and SCO. For elaboration, we take example of PTCL's license, which covers many services, including, local loop, LDI and value added services. Being the incumbent in fixed line sector, PTCL's effect on overall market is significant. This will be the driving factor for transport of femtocell traffic over broadband. Since we have seen that for deployment of femtocells, merging of mobile network and fixed network will eventually take place, however, since the existing licensing regime is split over service based categories, therefore it will be of concern how the two operators (Fixed line and Mobile) will cope up. Possible scenarios could be two, (1) inter-operator service level agreements, (2) mergers & acquisitions.

a) Whereas inter-operator agreements between fixed and mobile is concerned, certain elements of the whole network and services will have to be defined to the extent of responsibilities of each operator towards delivery of femtocell solution.
b) In the second scenario, we could also see mergers & acquisitions, this could result in companies having both fixed and mobile licenses. Mergers & acquisitions can be seen across the globe, and in a way helpful for those operators who want to provide multiple services and hold multiple licenses, in such an event it will be worth a look at a possibility of introduction of unified licenses.
c) Licensing requirement for femtocells can be considered depending on the regulatory regime being followed in the country. Spectrum holders/license holders can be relevied from having separate licenses for femtocell deployment. Other than this, no other entity can be allowed to establish, maintain or deploy femtocells even if they don't hold cellular license. However, entities having Fixed local loop licenses having interconnect for backhaul with the cellular operators can be allowed to install such devices having cellular operator on forefront for making application for permission from the Authority.

5.2.3 Equipment Registration/Approvals

As per present regulatory environment in Pakistan, Type Approval regulations and BTS site registration rules/policy of the Pakistan Telecommunication Authority applies. In this scenario, there are two options with regard to registration of Femtocell access points to be installed in user premises.

a) Femtocell access points installed by users
b) Femtocell access points installed by Operators
    - By CMOs, OR
    - By LLOs

For the femtocells access points installed by users, in general, when a user purchases such devices from authorized operator's sales points, it is expected that the devices are already type approved as per PTA regulations and are locked in such a way that the user is not able to configure or change any of the parameters of the device, except that it is the operator who is responsible for programming and configuration of the devices. Furthermore, it has to be decided whether to treat the devices as access points same as WiFi etc or as Base Station considering the power level of Femto devices is similar to that of smart phones and WiFi access points.

For the femtocells access points installed by operators, it will not be practical to maintain site registrations for each access point while having minimum power levels and negligible environmental factors, however, type approval regulations shall apply for each type and model of the access points. As regards management of access points, the operators must ensure effective management and accounting of all the access points and should be identifiable in its network.

As regards operation of the Femtocells by either CMO or LLO, the present regulatory regime in Pakistan may collide with the basic architecture of femto network, since it involves both fixed line operator (to provide broadband at user's end/backhaul to CMO's femto gateway) and CMO to manage and provide services through the same broadband. The cellular license issued in Pakistan does not entail the operator to provide fixed services such as PABX and similarly would also cause further deliberation on using femtocells and in the mean time fixed local local loop operators may not be able to meet broadband coverage in remote areas unless if it is a good market case while it is already noticed that broadband penetration in the country is still low.

5.2.4 Spectrum Utilization

Since spectrum is awarded to operators for operations in allocated bands, the femtocells installed by a particular operator will be desired to be operated in the same bands, thus maintaining ownership of such frequency spectrum with that cellular operator. Similarly, it will be the responsibility of the cellular operator for management, seamless connectivity of users moving in and out between femto zones and macro network. It is expected that the operators will ensure QoS and inter-cellular roaming, and handover issues are properly addressed. Similarly, Inter-operator, macro-femto, femto-femto interference issues must be properly addressed.

Issues of Consideration for Industry Feedback

Feedback on this study paper will be of great value to assess possible implications in using femtocells in the existing telecom market. Before finalization of the same, operators are expected to share their views on the subject and also provide their response to issues, highlighted in the table below. Additional comments may also be given (if any).

#	Issue	Comments
1	Who will be responsible for the complete deployment of femtocells? Mobile operators or Fixed line operators keeping in mind split level regulatory regime in Pakistan, i.e. Separate Fixed line &Mobile.	
2	What possible interconnect arrangements could undergo in case femtocells are provided through mutual agreement between CMOs and Fixed line operators?	
3	Split licenses for indoor and outdoor radio frequencies? Do you think it will help?	
4	Do you think that with the deployment of femtocells in residential/indoor environments can contribute to national exchequer in Pakistan?	
5	As per present regulatory regime, Mobile cellular policy and Fixed line policy co-exist. What possible changes should be brought to accommodate provisioning of femtocell based services and other converged services, or it is not required at all?	
6	What benchmarks should be defined for broadband/DSL/ISP backhaul so that it could be used for femtocells?	
7	Do you think femtocells, or any other small cells could result in better opportunity for CMOs in terms of revenue enhancement and better consumers services in Pakistan?	
8	What measures should be taken to accommodate femtocells, for their registration, type approval and commencement etc. (since femtocells are low powered, low range devices similar to WiFi hotspots, should only Type approval be necessary or requirements such as BTS site clearance etc should also be required)	
9	What other issues must be considered?	

10	What measures should be taken by the CMOs for femtocells, in terms of caller identity, location, national security requirements, emergency services, and reporting etc.	
11	What possible changes in CMO/LL licenses would be needed to accommodate femtocell services?	
12	Do you think it is better to deploy femtocells (frequency locked by operator) or UMA (Mobile access through WiFi which is free to use)? Technically and financially which of these would be better option?	
13	Do you think by using femtocells in indoor (residential/office) can effectively offload heavy traffic from macrocell network and could improve better QoS for macrocell users considering the case of Pakistan?	

CONCLUSIONS & RECOMMENDATIONS

Based on the discussion in preceding chapters, it is understood that Femtocells or any other small cells can provide opportunity for operators to provide better wireless services in indoor environments. High speed wireless data services and applications can be used by indoor consumers where macrocell network may not provide same speed. Operators can achieve cost savings on their macrocell network, similarly traffic can also be offloaded through utilization of fixedline alternatives providing better services for both home users and macrocell users.

Globally, each country has made its own arrangements to accommodate femtocells in their regulations and legal framework. In countries, which have converged regulatory regimes, such as, UK, Australia, USA etc. ***where operators which has both fixed line and cellular licenses (Converged) is responsible for overall femtocell deployment and provisioning.***

In Pakistan, a split regulatory regime is in place, i.e. Fixed line and mobile telephony for which separate licenses have been issued. The issue of "who is the owner of femtocells" in Pakistan will need to be decided through mutual agreements between Mobile or Local Loop operators or 'Fixed Mobile Convergence'. Since, femtocells fall under wireless telephony with backhaul management through Mobile networks therefore mobile operator has an important role to play, however, as the broadband/ISP for backhauling of femto traffic fall under local loop jurisdiction. Therefore such issues should be resolved through a comprehensive GoP policy after taking all stake-holders on board..

Possible solutions:

a. Fixed Mobile Convergence through merger of a fixedline and a mobile operator.
b. In instances where a single FMC does not exist, a mutual agreement between a fixedline and mobile operator may allow for wireless communication within building backhauled on fixed network but registered on a mobile platform.
    a. Interconnect between fixed and mobile operators would be needed for femto cell based services.
    b. Public Switch Cellular Network license in Pakistan prohibits fixed Microwave or P2P wireless links as last mile connectivity solution; these are only used for back-hauling.
c. Another alternate is that within broadband spectrum, 5MHz band may be allocated only for FemtoCells deployment to a new operator.

d. As regards to type approval for femtocell devices, it should be mandatory before deploying femtocells. Site registration requirements, as in the case of BTS, may not be made mandatory considering low power, low range specifications of such devices (as in the case of USA discussed in section 4.2 of this report), however the operators be required to provide complete details of femto cells (detail including but not limited to site id, location, services etc).

e. Before devising a policy or alternately through allowing through a regulatory framework on Femto Cells the Policy maker or the Regulator need to review the utilization and spread of Wi-Fi Access Points vis-à-vis Femto Cells.