

Deployment of Femtocells in Pakistan: A Consumer's Perspective

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Abstract—Femtocell base stations operate in the licensed cellular band, and are small and low power devices providing a feasible and low cost alternative to microcell deployment in order to improve indoor signal coverage at homes and small buildings. Despite many benefits that can be offered by wide scale femtocell deployment by network operators, there are some mandatory factors related to the end user perception in adopting and paying for the technology. In this paper, a thorough survey has been conducted to get an idea about the end user perspectives in regard to the deployment of femtocells. The survey contains a number of questions asked from over 150 participants from different backgrounds in order to determine the user opinion on installing femtocells and opting for data services offered by cellular network operators. Different categories have been made from the survey questions and results obtained are presented and discussed. Although the survey has been conducted in urban and rural areas of Pakistan, the survey can prove to be valuable in assisting network operators to adopt better marketing strategies outside Pakistan as well. Based on the general user response, it is evident that the users showed their interest in utilizing femtocells if better and low cost packages for using data services are provided. Furthermore, in those areas where DSL connectivity options are not available, users are willing to pay for femtocell base stations that can connect them to the cellular network via the microcell base station.

Keywords—Femtocell; Fixed Mobile Convergence; Cellular Networks

I. INTRODUCTION

Cellular networks have been providing new and innovative services to its users while on the other hand they are also facing expansion problems. In cellular networks frequency re-use, better signal strength in indoor environments, and capacity enhancements in populated areas keeping in mind the cost constraints are nontrivial issues. The radio signal carrying information degrades as it enters a closed structure for instance, a building. Femtocells are small base stations that operate in the licensed cellular bands. They are small and inexpensive devices similar in size to a Wireless LAN (WLAN) Access Point, and transmit at a low power and are to be placed in individual homes and backhauled onto the operator's network via conventional Digital Subscriber Lines (DSL).

Both the concept and the economics of femtocells constitute a radical arrival from traditional macro radio access networks, where each macro base station typically covers a fairly large geographical area and serves a relatively large number of users. Their strategic positioning inside the home and ability to be customized to the needs of individual consumers promise to rapidly make them major future components of the operators' business. Femtocells have gained a lot of attention from the research community due to the benefits offered in terms of infrastructure cost saving, load balancing, and

improved user experience indoors [1]. The idea of femtocells was presented in 1999; however, it started attracting wide spread market attention in 2007 [2]. Cellular operators have shown interest in the commercial deployment of femtocells in order to increase network capacity and improve coverage.

Since it is unlikely that the network operators are going to deploy additional microcell base stations in order to improve signal strength in indoor environments because of the substantial cost that is associated, femtocells provide a very low cost and feasible alternative. However, the wide scale presence of DSL being the prevalent means of access connectivity for consumers and providing data services at much better data rates than the cellular alternatives, mostly at a flat monthly rate, raises the question whether the end consumers are ready and willing to pay extra for provision and deployment of femtocells. Even though femtocells can offer better indoor reception for the consumer, still extra cost is associated if data services of the cellular network operator are used. Therefore, another important question is whether the consumers while having the option of utilizing data services using the existing DSL connection at a flat rate (which they are already paying) are going to utilize the data services of the cellular network operator (for which they have to pay extra) if the femtocell base station is deployed. Most of the new mobile phones in the market have a Wireless LAN interface and the users can use their mobile phone to connect with a wireless router to get access to data services and even make free voice calls using applications like Skype. Therefore, the end user perception about femtocell deployment can assist in answering these questions and help the network operators to shape their policies accordingly regarding wide scale femtocell deployment with better packages to entice the consumer in using their data services.

In this paper, a survey has been carried out using the most pertinent questions regarding femtocell deployment in order to gather the relevant statistics that portray the consumer perception in a way that can be helpful to the network operators to shape their marketing strategy regarding femtocell deployment in Pakistan. Section II of the paper gives a brief introduction about the generic network architecture that can be used for femtocell deployment. Section III gives specifics about femtocell deployment in Pakistan. Section IV describes the main advantages which femtocell deployment can offer. Section V contains the main contribution of the paper and gives the details of the survey and its results. Section VI has some recommendations based on the result of the survey. Section VII concludes the paper.

II. GENERAL ARCHITECTURE

For femtocell deployment, initially, a flat network architecture was proposed with IP used as a backhaul transport protocol to the operator's network. In the flat architecture a Security Gateway (SG) is placed between the cellular operator network and the femtocell that acts as the residential Node-B. In other proposed architectures, a Radio Access Network (RAN) Gateway is placed between the IP Network and the operator's core network [3][4]. When a RAN gateway is deployed some of the functions of the Radio Network Controller (RNC) are moved to the femtocell base station. These RAN gateways can incorporate substantial traffic from large number of femtocells on Iu over IP (the interface introduced for femtocell access to a UMTS network) [5]. The RAN gateway then forwards that traffic to the UMTS network on the Iu-PS (Iu- Packet Switched Interface defined for RAN gateway and Serving GPRS Support Node (SGSN) of a UMTS network) and Iu-CS (Iu circuit switched, interface between RAN gateway and MSC of the network) interfaces. Other interfaces include Iub (between the RNC and the Node B) and Iur (between RNCs in the same network). Iu interfaces carry user traffic (such as voice or data) as well as control information. The Iu interface is specified at the boundary between the Core Network (CN) and the RAN. The Iu-CS and Iu-PS interfaces are specified in the 25.41x series of UMTS technical specifications. The RAN gateway provides a simplified means to assist in wide scale femtocell deployment for cellular network operators with lower infrastructure expenditure. An example architecture can be seen in Fig. 1.

III. FEMTOCELL DEPLOYMENT IN PAKISTAN

In Pakistan, the Telecom sector is in the process of evolution and new standardized technologies are being adopted. End users can opt for different broadband packages that utilize ADSL with cheaper and more attractive offers and bandwidths of up to 50 Mbps. Above 60% of the population has access to voice and data services using either the cellular network or DSL. However, the issue of poor indoor reception usually thwarts the end user to go for data connectivity using the cellular network mainly because of lower data rates and the associated cost.

Since many popular internet applications especially streaming voice and video applications have high throughput requirements, the cellular network operators in Pakistan are gradually expanding their coverage and improving their capacity to accommodate more users and offer them higher data rates. However to fully satiate the requirements of the end users and encourage them to utilize the cellular networks for data services, the operators have to provide better packages and improve the link budget for indoor environments. Currently the data services are provided by the network operators using GPRS and EDGE in Pakistan.

In order to provide better throughputs, the planning has already started to upgrade their networks to UMTS and make

use of newer 3GPP [6] specifications like High Speed Data Packet Access (HSDPA), High Speed Packet Access (HSPA+), Long Term Evolution (LTE) and LTE Advanced. In order to improve the indoor coverage and signal quality, implementation of femtocell base stations shall prove to be a viable and low cost solution from the network operator's perspective. However, to find out the feasibility of mass deployment in the urban and rural areas surveys have been conducted in 9 major cities of Pakistan as well as the rural areas. In the survey, the opinion was inquired from more than 150 participants. The questions asked in the survey were prepared in such a way that the results can be utilized and prove to be useful to network operators outside Pakistan. In near future Pakistan Telecommunication Authority (PTA) is going to auction the IMT2000 frequency band for UMTS (WCDMA) services.

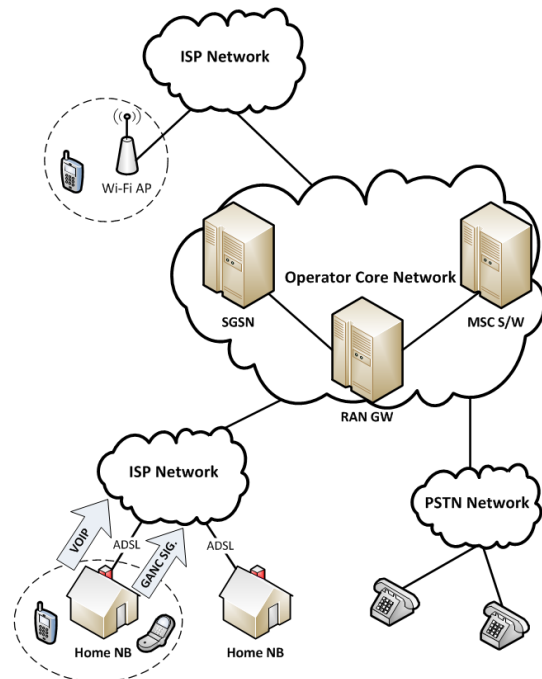


Figure 1 GAN-based Home NodeB architecture

IV. ADVANTAGE OF INSTALLING FEMTOCELLS

According to the statistics, above 70% calls are originated from homes and inside the buildings [7]. To mitigate the issue of poor indoor reception microcell installation is a solution with substantial cost associated with it. The femtocell base station installation in a home or a building does not only ensure lower infrastructure expenditure but can also relieve the traffic from the microcell base stations [8]. The reason is that the femtocell base station is connected to the available DSL connection and all the user traffic is backhauled to the cellular network directly using that connection. Even users can share the cost of femtocell implementation if the femtocell base station is provided at a lower cost by the operator or provided freely as a part of an attractive package.

By installing Femtocells, in addition to better voice quality, multimedia and other data traffic can be accessed at higher

data rates because of improved Signal to Noise Ratio (SNR). Femtocells will deliver converged services (voice, video and data services) at home and will enable users to have a seamless experience across both outdoor and indoor environments [9]. Because of a lesser distance between users' mobile device and the femtocell, the user device can connect to the femtocell base station using lower transmission power hence reduced battery consumption and lower probability of health concerns.

V. CONSUMER PERSPECTIVE SURVEY

The survey was conducted in cities of Karachi, Lahore, Islamabad, Rawalpindi, Quata, Bannu, Peshawar, Mardan and Nowshera. In this section, questions from the survey are categorized in different sections. Each section has the relevant questions tabulated, the tables representing the questions and the percentage response, and finally the graph giving an insight of the received response.

A. Connection and Reception

Five questions asked in this category of survey are listed in Table I. Most of the questions asked were about the connectivity options that a user has and about the cellular service signal reception. In Table II, the results of the survey are tabulated and based on the results (answers), percentage plots are made as shown in Fig. 2.

Question 4 is particularly worth mentioning because it is obvious from the results that people are interested in paying more in order to get a better signal strength at their homes i.e. for indoor usage of cellular service.

TABLE I CONNECTION AND RECEPTION RELATED QUESTIONS

Q.No	Question	Answer Choices	Remarks
1	Do you have a DSL connection at home?	i. Yes ii. No	
2	Do you use your cell phone to access data services i.e. access the internet?	i. Yes ii. No	
3	Do you have a good signal reception at your home (indoors)?	i. Yes ii. No	
4	Would you prefer to have good/better signal reception at your home for a one off payment?	i. Yes ii. No	
5	Do you intend to receive good signal reception at home only to receive phone calls or also to make phone calls using your cell phone?	i. Yes ii. No	Answer if "Yes" to 4

TABLE II RESULTS OF THE CONNECTION & RECEPTION RELATED QUESTIONS

Question No.	Answer Percentage	
	Choice (i)	Choice (ii)
1	93%	7%
2	40%	60%
3	58%	42%

4	79%	21%
5	86%	14%

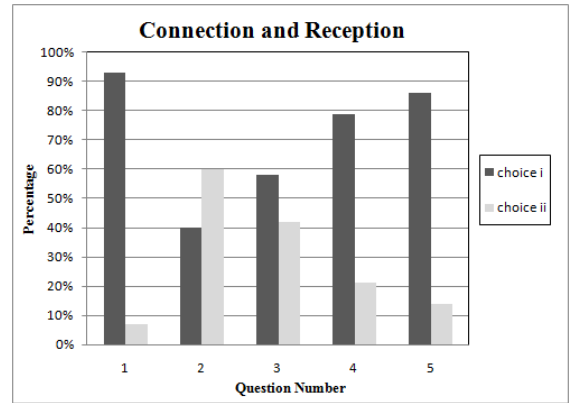


Figure 2 Answer Choices Plot for Table II

B. Making Phone Calls

This section categorizes the questions asked about using which service for making phone calls. Table III tabulates the questions asked from the users. Based on the questions asked, the results are obtained as shown in table IV. Fig. 3 depicts the corresponding bar graphs for each question asked.

TABLE III MAKING PHONE CALLS RELATED QUESTIONS

Q.No.	Question	Answer Choices
6	When at home, do you primarily use your landline phone to make calls more often or do you use your mobile phone to make calls?	i. Landline ii. Mobile Phone
7	Does cost of making the phone call affect your priority in any way?	i. Yes ii. No
8	Does the reception quality of your mobile phone affect your priority in any way?	i. Yes ii. No

TABLE IV RESULTS OF THE MAKING PHONE CALLS RELATED QUESTIONS

Question No.	Answer Percentage	
	Choice (i)	Choice (ii)
6	60%	40%
7	73%	27%
8	76%	24%

Question 8 in this category is important because users are interested in changing their means of making a call based on the reception quality. Poor reception quality usually leads to calling from another source, landline for instance, rather using the mobile phone.

C. Accessing Internet

Data services and internet related questions are listed in this category as Table V shows. Based on the feedback, the results of the questionnaire are tabulated in Table VI. Finally, the results are plotted in Fig. 4.

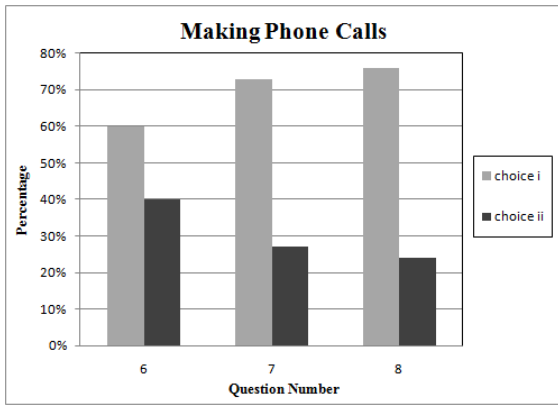


Figure 3 Answer Choices Plot for Table IV

As the results show, most of the users are interested in using mobile phone for internet access. The principle reason behind choosing a mobile phone for internet access is the associated mobility and convenience. Also, users most of the time use both cellular data service and a WLAN for mobile internet in phones though there isn't a particular higher priority for either one. Both are used by most of the users, most of the time. For better indoor reception and hence accessing data services, almost half of the users who were part of the survey are willing to pay more. The results obtained and discussed show that the deployment of femtocells in an indoor environment is very likely in near future.

TABLE V ACCESSING INTERNET RELATED QUESTIONS

Q.No.	Question	Answer Choices
9	When at home, which device do you use to access the internet more often i.e. your mobile phone or the DSL connection?	i. Mobile Phone ii. DSL Connection
10	In case it's the mobile phone, do you connect your cell phone to the WLAN router and access the internet or do you use the services of your cellular operator or both?	i. WLAN Router ii. Cellular Operator iii. Both
11	In case you don't use your mobile phone to connect to the internet, is any one of the following any reason for you to do so?	i. Poor indoor reception ii. Comparatively higher cost of using data services from cellular operator
12	Would you prefer the convenience of using mobile phones to access the internet even at a comparatively higher cost when compared to the DSL connection? (if the option of femtocell is available and as a result good reception is available)	i. Yes ii. No

13	What percentage of time do you utilize accessing data services each day using your cellular operator while at home compared with the total time utilized throughout the day doing the same?	i. 10-20 % ii. 20-40 % iii. 40-60 % iv. 60-80% v. 80-100%
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TABLE VI RESULTS OF ACCESSING INTERNET RELATED QUESTIONS

Q.No.	Answer Percentage				
	Ch. (i)	Ch. (ii)	Ch. (iii)	Ch. (iv)	Ch. (v)
9	79%	21%	-	-	-
10	29%	27%	44%	-	-
11	48.3%	51.7%	-	-	-
12	48.4%	51.6%	-	-	-
13	41.8%	20.6%	22%	12.1%	3.6%

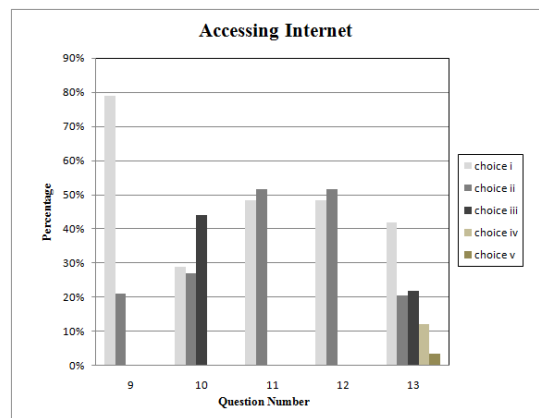


Figure 4 Answer Choices Plot for Table VI

D. Femtocell Installation

Table VII lists the questions asked about the deployment of Femtocells. The results of the survey are tabulated in Table VIII and the corresponding plots are shown in Fig. 5. Different inferences can be made from the results in this category of the survey. Users are interested in installing femtocells to get good reception for the signal itself as well as to use the data services. Half of the users in this case chose for both options. Question 15 is important because it reflects user opinion on installing femtocells at their homes—or any indoor enclosure for that matter—in case DSL services are not reachable especially in rural areas.

One major reason not to opt for a Femtocell deployment at home is the price of the device itself although the results are comparable with another reason for not using a Femtocell device at home i.e. the data service charges set by the operators. Users will be interested in deploying a Femtocell at their homes if the operators can lower the data services charges or introduce reasonable data packages. Finally, most of the users are ready to share their Femtocell service with other external users even though the limited user capacity is explicitly mentioned in the question.

TABLE VII FEMTOCELL INSTALLATION RELATED QUESTIONS

Q. No.	Question	Answer Choices
14	If you would opt to install a femtocell base station, would it be because you prefer to have good signal reception for making/receiving voice calls using your cell phone or because you prefer to access the data services or both?	i. Good Signal Reception ii. Access Data Services iii. Both
15	If you don't have DSL connectivity because it is not available in your area, would you consider buying a Femtocell Base station to get better reception and high speed data services?	i. Yes ii. No
16	What is the main reason for not opting for a femtocell solution?	i. Cost of Femtocell base station ii. Cost of data services provided by the cellular operator
17	Would any of the following make you reconsider about getting a femtocell solution?	i. Femtocell base station provided free of cost by the cellular operator ii. Lower charges for data services or better packages at lower cost iii. Data services provided free of cost by the cellular operator
18	In case your decision to install a femtocell is to improve the signal reception for making/receiving phone calls, would you still sometimes use the facility to access data services from your cellular operator?	i. Never ii. Maybe iii. If a good offer is available iv. don't know
19	In case DSL connectivity is not available in your area for some reason and your femtocell has a direct wireless connection to the nearby macrocell base station, would you be willing to share your femtocell coverage with external users who might need to connect to the nearby macrocell base station by using your femtocell as one of the relay devices to send their signal across (Considering the fact that a femtocell base station might not support more than 4 users at a single instant)?	i. Yes ii. No

TABLE VIII RESULTS OF FEMTOCELL INSTALLATION RELATED QUESTIONS

Q. No	Answer Percentage			
	Ch. (i)	Ch. (ii)	Ch. (iii)	Ch. (iv)
14	24.8%	24.8%	50.4%	
15	84.4%	15.6%		
16	52.8%	47.2%		
17	35.1%	40.3%	24.3%	
18	17.9%	28.5%	47.0%	6.6%
19	64.2%	35.8%		

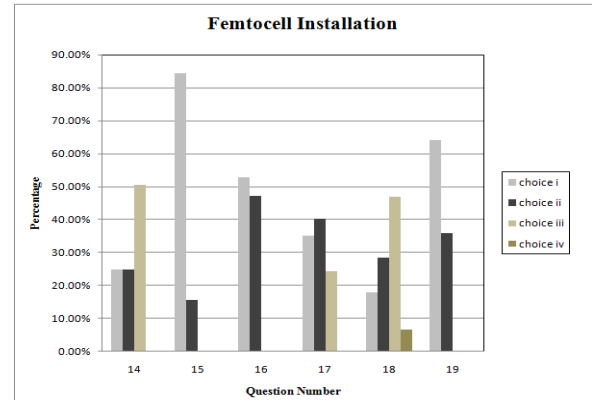


Figure 5 Answer Choices Plot for Table VIII

E. Skype Users

In this category of the survey, questions are asked from around 100 users who used Skype in their smartphones and are different from the pool of users who were asked Questions 1-19. Table IX lists the questions that were asked. The results obtained are tabulated in Table X and based on those results; the corresponding plots are drawn as shown in Fig. 6.

More than half of the users didn't use Skype application in their phones. Half of the users with Skype installed in their smartphones were interested in using the application for making free local and international phone calls and most of them were interested in paying for deploying a femtocell base station at their homes in order to get better reception for faster data services.

TABLE IX SKYPE USER RELATED QUESTIONS

Q.No.	Question	Answer Choices	Remarks
20	Do you own a smart phone that has Skype installed?	i. Yes ii. No	
21	Do you use your Skype service to make free calls nationwide and internationally?	i. Yes ii. No	Answer if "Yes" to 20
22	Would you opt to pay for a femtocell base station to get better indoor coverage as well as faster data services?	i. Yes ii. No	Answer if "Yes" to 21

TABLE X RESULTS OF SKYPE USERS RELATED QUESTIONS

Question No.	Answer Percentage	
	Choice (i)	Choice (ii)
20	44.30%	55.70%
21	50.60%	49.40%
22	65.50%	34.50%

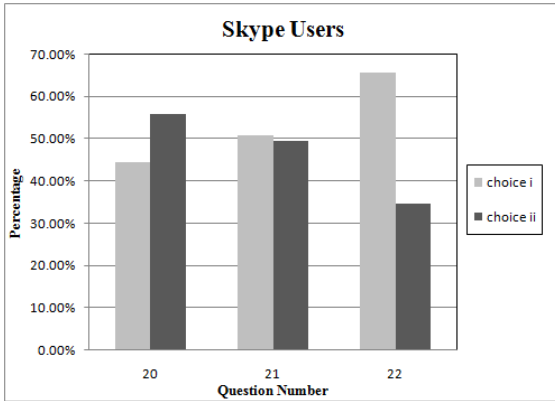


Figure 6 Answer Choices Plot for Table X

VI. RECOMMENDATIONS BASED ON SURVEY RESULTS

Based on the results of conducted survey, it is evident that the potential consumers of femtocell based services are interested in getting data services from the cellular operators at a lower cost. The response to Question 19 suggests the willingness of most of the end consumers to share their femtocell coverage in case there is no DSL connectivity available especially in rural areas, in order to indirectly access the macrocell base station or Node b. This option if exercised shall have an impact on the overall deployment architecture since multihop communication can be considered in order to give access to users to indirectly access the macrocell base stations or Node b's via connected femtocells. Furthermore, Hybrid Access Points (HAPs) can be considered in the future that can give access to WLAN users as well as femtocell users and backhaul their traffic to the respective networks via a single, high bandwidth DSL connection and has the ability of traffic differentiation.

VII. CONCLUSION

Femtocell deployment in urban and rural areas in Pakistan is expected in the near future. It is clear that a wide scale implementation shall benefit the operators in terms of substantial infrastructure cost savings. However, the end user can also benefit in terms of improved indoor signal reception for voice and data access. The results of the survey carried out show that the users are willing to acquire femtocell based solutions if cost effective and better packages are offered by the network operators. The results of the survey can prove to be a good yardstick for network operators in and out of Pakistan to shape their marketing strategies in an effective manner in order to increase the utilization of their networks in terms of substantial data services and as a result more revenue generation.

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