Signal Behaviour in an Indoor Environment: Femtocell over Macrocell

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Abstract— **In this paper, we consider femtocells over macrocell for improved signal, good quality of voice calling, data and Internet use in the indoor environment, where there is poor reception of signals. Mobile networks have become most frequent means of communication in well-developed areas and some other places in the world for communication and business purposes. Therefore, the deployment of femtocells has drawn the attention of mobile industry experts, researcher and other standardization organizations over macrocells. The interesting part of the femtocell is that it improves coverage, enhances the data rate at the indoor environment and more so used for security purpose. We focus on benefits of deployment of femtocells and how femtocells can optimize the total capacity of mobile network where there is poor reception. In this paper, we simulate the signal behavior of femtocell over macrocell in an indoor setting, to illustrate that femtocell improved signal and voice calling in an indoor environment.**

Keywords – Deployment of Femtocells (DoF), Benefits of Femtocells (BoF), Signal (SIR), Quality of Service (QoS), Quality of Voice Call (QVC)

I. INTRODUCTION

The mobile communication networks have become one of the necessities in the human race, such as Internet users, educational resource for learners and business purposes. These mobile networks have reduced the need for travel, and promotes voice calling for either home or office user. Most offer, an indoor signal suffers poor reception and call distortion due to the requirement of number of Macro base station site from the mobile providers, which is very expensive. An investigation carried out by the Femtoforum show that there will be a need for increase in voice calling at the indoor environment [1]. The deployment of femtocell is favorable over macrocell at the indoor environment for coverage and system capacity in a low cost manner. Femtocells focus on the quality of voice calling, data and improved signal coverage in an indoor environment for all mobile users.

According to Femtoforum [1], femtocells are mobile technology that generates coverage, capacity over the Internet backhaul with full operating capacity under the licensed spectrum at a low price for the end user's. Withal, they are small base station at the indoor environment, installed by the end user and connected through the Internet, access to the mobile provide [2]-[6]. Other authors used MATLAB to enhance the performance of the cellular systems when implementing the technology of the Femtocell in the system to optimize the frequency spectrum [16]. Dynamic frequency planning in a macrocell / femtocell scenario compared with other frequency assignment strategies were analyzed [17].

Thus, femtocell support at least four to five at the indoor environment and is applied to residential, enterprise, hot spot and metro. The values of communication as linked to, such as voice calling, quality of service, and economic expansion of a country. The significant of femtocells in mobile network boost economic growth and benefits. Figure 1, illustrates the application of femtocell in a home setting, connect to the mobile provider through the broadband access.

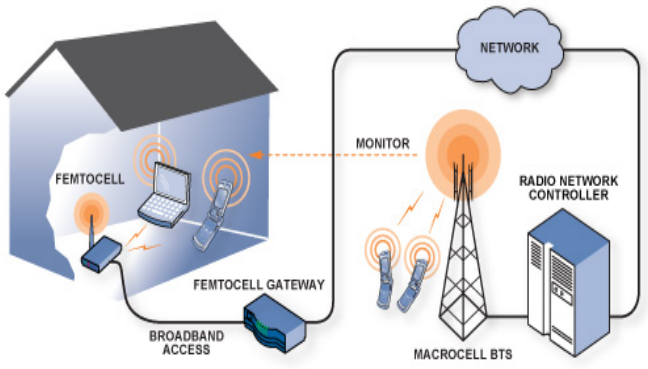

Fig. 1: Illustration of femtocell in a home setting [7]

The economic value of the femtocell is growing fast, however, increasing revenue for mobile provide. The Femtoforum launch the market report status on femtocell, and this has shown that it increases mobile revenue [1]. In fact, it reduces operational cost, infrastructure and maintenance cost for mobile provide. More so, it performs certain functions of which macrocell may not perform such as it guaranteed good connectivity, home security, remote control of home appliance and quality of voice experience.

A part of all this, it lessens the traffic load over macrocell and increase the performance of the mobile provider. Though, it faces a technical challenge which is caused due to use of the

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same licensed band with the existing spectrum of macrocell and ad hoc deployment of femtocell, which is led to interference management. But they are needed for mobile provider to investigate in order to deploy femtocell successful for improved coverage at the indoor environment at low cost. However, the deployment of femtocells, still provides a better coverage in the network

The mobile traffic grew widely over the last decade due to the profitable rate flat launch by mobile service, and such request should be met by new mobile communication systems, as well as increasing the incomes. Hence, the achievement of the wireless network will depend on the providing a broadband access for mobile user, where costs per bit error rate are low [8].

Often, mobile traffic is highly demanding in homes and office environment and according to [9], more than 80% of the mobile traffic is used in an indoor environment. The new technology will offer solution for home and office, where there will be an improved reception of signals in an indoor and these promotes cost effective for the network users. The target of service provider is to satisfy the need for the high demand of mobile data in an indoor environment and also to offer an added valuable service.

Mobile operators benefit most from these new technologies known as femtocell in such a way that the operator has enough saving on coverage and profit, no more electricity bills and no time wasting on problems. Finally, its provide broadband access point in order for a connection with a satellite backhaul, for instance, inside an airplane, complex, shopping mall, train and war ship respectively. These access points are modelled in linked to the business model.

The rest of this paper is structured as follows. Economic impact of femtocell is in section II. Femtocell over macrocell deployment are explained in section III. The notation and system analysis were discussed in section IV. The experimental results are carried out in section V. The conclusions are drawn in VI.

II. Economic Impact of Femtocell

The economic impact and benefits of deploying femtocell in place like Europe, North America has radically reduced price of the building macrocell site and encourage more voice calling, internet in an indoor setting with lower price. However, the successful deployment of femtocell in Europe, and America, has improved voice calling, better signal at the indoor setting, and more so, increase revenue for mobile provide. This can also be applied to Africa country as a whole for better communication in an indoor environment and for security purposes. We outline the potential benefits of deployment of femtocell in the home or office to end user. Here show the deployment of femtocell network in figure 2. This illustrates the percentage of femtocell deployment in the world. In Africa it is 1 percentage of femtocell deployment. Mostly the developed countries or continents have deployed Femto cells. There is room for improved usage of Femto cells in Africa.

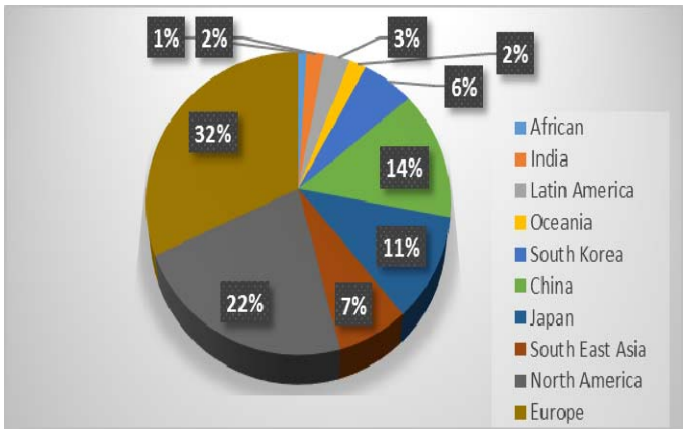

Fig. 2: Femtocell deployment

The benefits of Femto cell deployment are listed below [1], [10]-[11].

- Improved indoor coverage - femtocell extend the service of mobile provider at the indoor comparing to macrocell, in-building coverage can be an issue. In macro-perspective, the propagating through the wall is undesirable. Users try to keep interference inside and attenuation outside and it is extremely good for femtocell to operate.
- New applications - it supports a wide range of new applications for a user, such as a home media server, child monitor, home security, video door bell and game, and many more. The listed applications are applicable to both home and office environment.
- Improved voice calling - here the base station is closer, the quality of sound will be improved and higher data rate to be used in the indoor.
- Reduction in power utility – in such that the base station is closed, this result to long life battery.
- Customer satisfaction - customer derives satisfaction on the improved signal coverage and higher data usage and other service it provider at the indoor environment rather than the macrocell or Wi-Fi network.

Here, listed below the economic impact to mobile provider:

- Increase in revenue --- the deployment of femtocell brings about increase of mobile revenue due to additional service deliver from the femtocell to end user. These additional services attract the user which led to increase in revenue of the mobile provider.
- Cost reduction -by deployment of femtocell, it reduces building of macrocell sites, rentage of sites and pose challenges in site purchasing for mobile operators. With

this result, it has been providing a cost efficient and capital expenditure savings for mobile operators.

- Product satisfaction - when comparing other cellular service provider, femtocell provides more effective service and higher throughput among others.

III. FEMTOCELL OVER MACROCELL

Thus, a femtocell is aimed for cognitive abilities for the purpose of mobile communication, traffic loading, capacity, and coverage optimization over others mobile cellular network at the indoor [2]. Most often Wi-Fi network is popular accepted for all cellular service providers due to is signal strength, but femtocell network is much better off in terms of improved signal strength, security purpose, and voice calling service at home or office environment. However, the received signal strength gets improved due to the functionality of femtocell as a base station at the indoor environment. A macrocell transmit in a wide range with high transmission power that cover up to about 20miles radius due to a base station.

Nos	**Table 1: Femtocell and other cellular networks**		
	Table column subhead	***Femtocell***	***Macrocell***
1	Data Rate	45Mbps	Non
2	Installation	Customer	Operator
3	Rent of Site	No Site Rentage	Rentage of Site
4	Operating Frequency	2,6GHz	5GHz
5	Power Ranges	10dBm	25dBm
5	Primary Service	Quality of voice calling, Multi-media, Video and security	Data and voice calling

Table 1, show the comparison between femtocell and macrocell [12]. Femtocell operates with a low transmission power in order to avoid interference with similar, nearby device and offer data rate ups to 45Mps, it increases more than that in advance LTE and support video bell door. The most remarkable about femtocell is the valued added service render to the end users at the home or office environment. It is a service that a mobile provider is always enthusiastic to integrate as much as possible.

IV. NOTATION AND SYSTEM ANALYSIS

Here, we present the system notation, and parameter for experimental results. Our primary objective is to achieve an improved signal and quality of service at the indoor environment. The estimation of SINR [13] is highly important, which is expressed as (1):

$$Sinr = \frac{g_{fbs} p_{fbs}}{\sigma + \sum p_{fbs} + \sum p_{mbs}} \qquad (1)$$

p_{fbs} ……Transmitting power of femto base station

p_{mbs} …… Transmitting power of macrocell base station

g_{fbs} …… Channel gain

σ …….. Noise.

In this paper, we used the path loss model [14]. These path loss models are approximations of the instability of signal behavior in an indoor environment. Therefore, the path loss is given [14] in the equation (2):

$$PL(dB) = \max(15.3 + 37.6Log_{10}(d)), 38.4 + 20Log_{10}(d) + 0.7d_{2D,indoor} + 18.3n^{\left(\frac{n+2}{n+1}\right)-0.46} + qL_{iw} + L_{ow1} + qL_{ow2} \qquad (2)$$

Where, *PL* is the path loss model

n ---- Number of penetration floors

q ---- Number of walls in the flats

L_{iw} ------ Penetration Loss of the wall that different the apartment

$0.7d_{2D,indoor}$ ------ Penetration Loss by the walls inside the flats

d ----- Distance between transmitter and receiver in meter

L_{ow} --------- Penetration Loss of outdoor wall

L_{ow} and L_{iw} are set to 20dB and 5dB respectively.

Then, we presumed that the capacity saved as the network throughput [15], mathematically it is given as (3):

$$T = \beta \log_2(1 + \sin r) \qquad (3)$$

Where T is the throughput and sinr is the signal. Here, a number of femtocells are selected to be used in the indoor environment with equal service provider in this area and one outdoor macrocell. Each femtocell act well as defined in the experiment, the parameters for the system analysis are shown in Table2.

Nos	Table 2: Simulators Parameters	
1	Parameters	Values
2	Scenario size	350x350
3	Macrocell Base station	1
4	Femtocell as a Base Station	1
5	Bandwidth	5MHz
6	Noise	-174dBm/Hz
7	Macro Tx Power	43dBm
8	Femto Tx Power	10dBm

The system simulation uses Matlab as a model of operation to analysis the signal behavior of femtocell over macrocell in

an indoor environment. The real life network model takes a series of events to achieve the main objective of the goal of the application of a femtocell.

V. Conclusion

In this section, we observed the simulation results of deployment of femtocell for improved signal and quality of voice calling. We consider the parameters and equation in section IV. The simulation results here show the signal behavior that aids to appreciate the deployment of femtocell over macrocell in an indoor.

Based on the result, figure 4 illustrates the deployment of femtocell in the residential area. The colour blue indicates Femto access point (FAP), this is the subscriber of femto user and other colour indicate nonsubscriber. Here, the FAP is randomly scattered around the area.

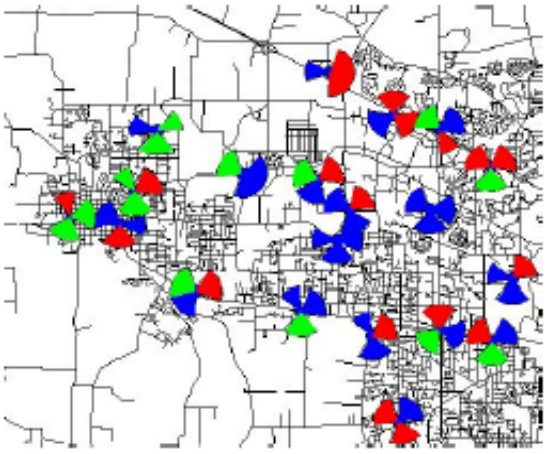

Fig 4: Deployment of femtocell network in residential area

With the simulation result shows in figure 5, bit error rate against the signal. We considered the bit error rate at the indoor environment and this is the major parameter in data transmission and communication system.

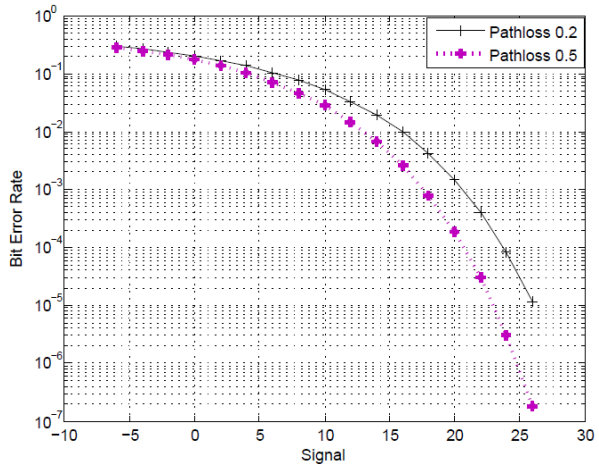

Fig. 5: Shows the relationship between BER against signal

From the result, we observed that the bit error rate is low and this promotes voice calling. The system throughput is obtained by a reduction of bit error rate.

In figure 6 of the result, we show the throughput of both femtocell and macrocell against signal in order to achieve a better signal strength at the indoor environment. With the result, it is observed that the throughput femtocell enhance an improve coverage in an indoor environment which promote quality service performance for Femto user.

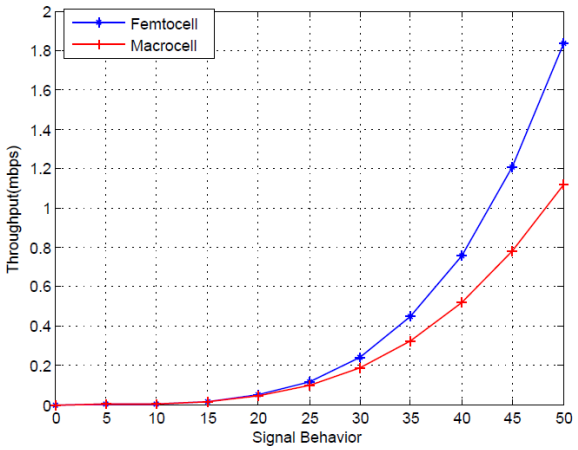

Fig 6: Illustrate signal behavior of femtocell over macrocells in an indoor.

VI. Conclusion

We observed that the signal performance of femtocell technology enhances an improved network and Internet user in an indoor environment compare to macrocells and it seems femtocells is more efficient to deploy. The deployment of femtocells over the existing macrocell has brought efficiency and profitable solution for mobile operators. Femtocell have attracted the attention of service providers due to the valuable service and decrease of related energy consumption.

More so, the performance capacity is attained because of the closeness of the Base Station (BSs) to the users in an indoor setting for improving the quality of signal and data coverage.

The main concern should be the technical challenge of femtocell and optimization within the cellular network in order to deliver high quality of service and improve coverage in an indoor setting. However, the deployment of femtocell will continue to play a vital role in the market for mobile operator's network.

ACKNOWLEDGEMENT

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