Deployment of Femtocells in Broadband Wireless Network: Advantages

Baisakhi Maity

School of mobile computing and communication, Jadavpur University

Kolkata, India

baisakhi.maity@gmail.com

Abstract— **Femtocell is a low power base station which is deployed inside the buildings to enhance the indoor coverage and signal strength. In this paper, the SINR, packet loss, and throughput are observed inside a building area by varying the user density and number of channels. The building area is far away from macro base station and resides at the edge of macro base station's coverage area. The whole design and simulation is done in Qualnet 5.0.**

***Keywords*— Femtocell, Macrocell, SINR, Packet Loss, Throughput, Qualnet 5.0.**

I. Introduction

Mobile network services become indispensable for everyone's life in today's world. Maximum people stays indoor region about 2/3 rd portion of a day. Therefore a huge amount of phone calls and data services are done in indoor region [1]. The indoor wall penetration loss and low signal strength hampers the communication. Sometimes the distance between the end users and Macro Base Station (MBS) also affects the network coverage inside a building. Deployment of femto cells is one of the solutions to overcome such problem. A Femto Base Station (FBS) is a low power base station which is deployed inside the buildings to enhance the indoor coverage and signal strength. FBSs, also known as 'home base station', are cellular network access points that connect standard mobile devices to a mobile operator's network using residential DSL, cable broadband connections, optical fibers or wireless last-mile technologies. Figure 1, depicts a femto cellular network [2].

A. Advantages of femtocell

The main advantages of Femto cellular network is as follows:

• A FBS provides indoor coverage for locations where macro cells cannot thereby overcoming the dead zone problem.

• It offloads traffic from the macro cell layer and improve macro cell capacity.

• There is a growing demand for higher and higher data rates. Due to the high penetration loss, high data rate services cannot be provided to indoors apart from those areas near windows that are facing a macro cell site. This is because high data rate requires high performance RF links. High data rate services such as those facilitated by HSDPA are the key drive of femtocells.

• Femto cells can provide significant power saving to UEs (user equipments). The path loss to indoor FBS is much smaller than that to the outdoor MBS, and so is the required transmitting power from UE to the FBS.

• As FBSs need to be switched on only when the users are at home (for home femtocells) or at work (for enterprise femtocells), the use of femtocell is 'greener' than macrocells [2].

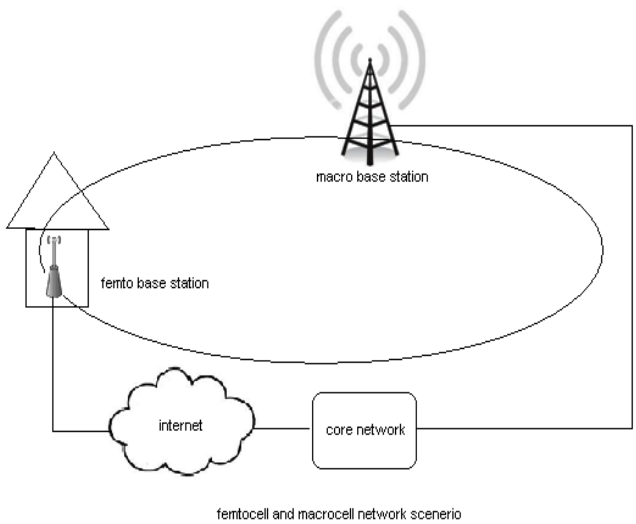

Fig. 1 Macro Femto Network.

In Qualnet 5.0, a scenario is designed to establish the fact that FBS is more useful in indoor region to provide better signal strength and higher data rate. The MBS only provides the services to the edge of the building. But as deep you enter in the building you cannot receive any signal. To provide the network services inside the building 9 FBSes are placed. The FBSes provide better signal coverage inside the building which is understood by observing the different parameters' results.

II. Scenario Architecture and System Model

In this paper, a building having area of 50m X 50m area is considered inside which 9 femto cells are placed uniformly. The MBS is situated more than 110 meters away from the building's furthest corner. The MBS is a WiMAX [3] base station, which transmitting power is 46 dBm and the antenna height is 32m. The transmitting power of the femto cell is 20 dBm and the antenna height is 1.5m. The entire scenario has been designed in Qualnet 5.0 simulator.

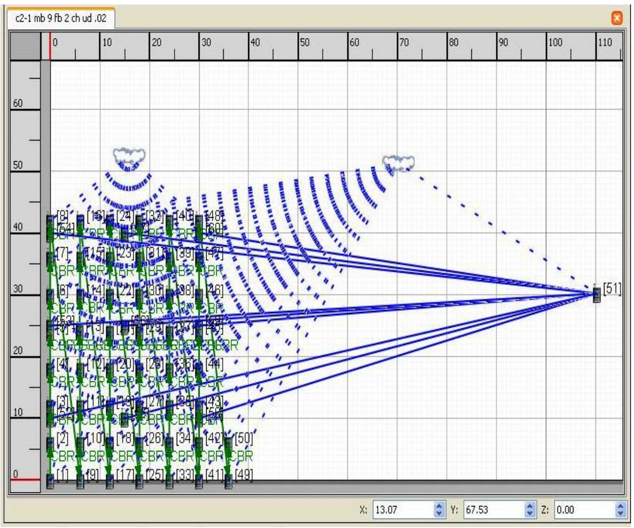

Fig. 2 Macro Femto Deployment in Qualnet

To maintain the real world application, the indoor pathloss model is considered. In this model, two pathloss equations are considered. Equation (1) calculates the pathloss from the MBS to the femto user while equation (2) calculates the pathloss from FBS to the femto users [4].

$$pathloss_{macro\text{-}femto} = 15.3 + 37.6 \log_{10} r + 10 \quad (1)$$

$$pathloss_{femto\text{-}femto} = 38.46 + 20 \log_{10} r + 0.7r \quad (2)$$

where ‘r’ implies the distance between the nodes.

To study the result five different cases are considered and for each case 3 different User Densities (UD) are taken.

Case 1: Both macro and femto base stations are using co-channel. Due to the co-channel interference the call quality of the femto users degrade.

Case 2: 1 channel is dedicated to the MBS and another channel is shared by the 9 FBSs. Performance of femto cells is observed to enhance with respect to the scenario in Case 1 but the overlapping of the coverage area of adjacent femto cells leads to a significant amount of co-channel interference. Co-channel interference in reduced introducing more than one channel and distributing them among the femto cells such that no two adjacent FBS operate in the same channel.

Case 3: 1 channel is dedicated to the MBS and 2 other channels are used by the 9 FBSs.

Case 4: 1 channel is dedicated to the MBS and 3 other channels are used by the 9 FBSs.

Case 5: The MBS uses 1 channel while 4 other channels are used by the 9 FBSs.

III. Results and Discussion

A. System parameters

The WiMAX system parameters are chosen based on IEEE 802.16 protocol and are shown in the Table I [3, 4].

TABLE I
SYSTEM PARAMETERS

Parameter	Value
Macrocell transmit power [dBm]	46
Macrocell antenna height [m]	32
Femtocell transmit power [dBm]	20
Femtocell antenna height [m]	1.5
Path loss model	Indoor pathloss model
Noise factor [db]	10

B. Graphical results

The results are shown on the basis of three parameters i.e. mean SINR, mean % of packet loss and mean throughput.

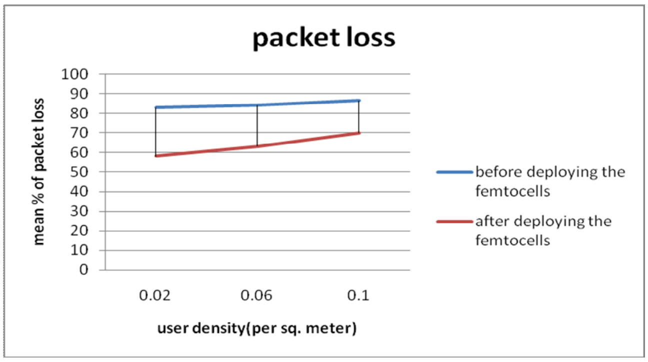

Fig. 3 graph of mean % of packet loss for different user densities

In Figure 3 a comparative result of the mean % of packet loss is shown when only macro base station is used and when 1 macro base station and 9 femto base stations are operating in 5 channels. From the graph, it can be seen that % of packet loss reduces inside the building when femtocells are used. From this result, it can be easily deduced that femtocell enhance the signal strength and coverage area inside a building.

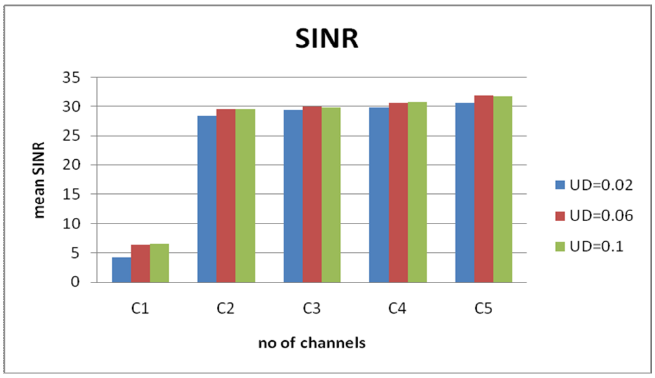

Fig. 4 graph of mean SINR for different no of channels

In fig 4, the mean SINR variation is shown for previously said 5 cases. SINR is the ratio of the received signal strength to the amount of noise present in the signal. Therefore SINR improves when either received signal strength increases or interference reduces. In case 1, co-channel interference increments the noise value so SINR decreases. From case 2, as MBS and FBSes work on different channel interference reduces significantly and SINR improves. In case 3-5, the channel allocation is planned such a way that no adjacent femtocell cannot operate same channel. This type of frequency planning helps to reduce the interference and increase the average SINR value of the system.

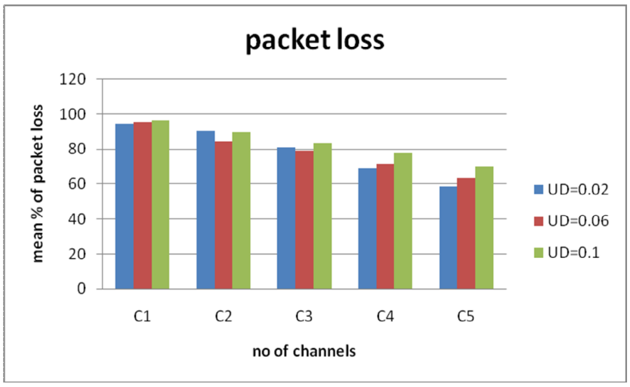

Fig. 5 graph of mean % of packet loss for different no of channels

In fig 5, the mean % of packet loss is shown for previously said 5 cases. % of packet loss is calculating by counting the number of packets are lost during the data transfer. Packet loss is happened due to congestion, interference, smaller coverage area etc. When number of channel increases the interference and congestion decreases. Therefore % of packet loss reduces. The result improves in every case and supports the FBSes effectiveness.

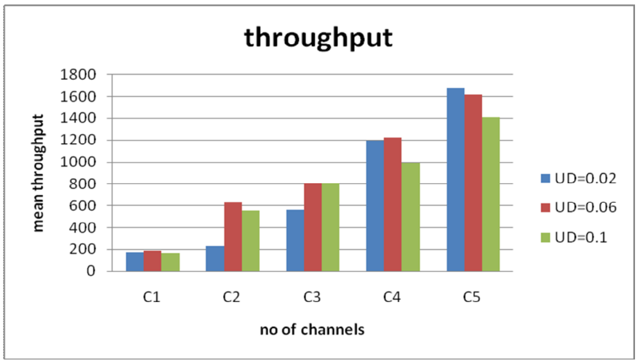

Fig. 6 graph of mean throughput for different no of channels

In fig 6, the mean throughput variation is shown for previously said 5 cases. Throughput means number of bits is sent per second. Increment of throughput ensures higher data rate and better signal quality. From the graph, it is shown that throughput significantly increases when MBS and FBSes are operating in different channels. The frequency planning also becomes very much beneficial as per as throughput is concerned.

From the above graphs, it can be said that as the number of channel increases the interference reduces. Therefore the % of packet loss reduces and SINR, throughput increases. From the graphical results it can be concluded that the best result is shown by case 5. The cause behind it is use of 5 channels reduces the interference among the adjacent femtocells.

IV. Conclusion and Future work

During this experiment it can be seen that indoor signal strength is enhanced using femtocells but when more than one femtocell is present in the closed vicinity a significant amount of interference is occurred. It can be reduced by allowing more number of channels but channels are very limited resource. Therefore it should be used more efficiently and for this purpose the channels are distributed among the FBSes in such a way that no adjacent FBSes has same channel. This type of frequency planning reduces co-channel interference effectively. In future to make the system more efficient a power control algorithm can be used.

Acknowledgment

The author deeply acknowledges the support from DST, Govt. of India for this work in the form of FIST 2007 Project on “Broadband Wireless Communications” in the Department of ETCE, Jadavpur University.

References

[1] *Shu-ping Yeh and Shilpa Talwar, Intel Corp, Seong-Choon Lee, KT, Heechang Kim, Telcordia,* “WiMAX Femtocells: A Perspective on Network Architecture, Capacity, and Coverage”, IEEE Communications Magazine , October 2008.

[2] Jie Zhang and Guillaume de la Roche, University of Bedfordshire, UK, “FEMTOCELLS: TECHNOLOGIES AND DEPLOYMENT”, WILEY publications, 2010.

[3] “802.16-2009 - IEEE Standard for Local and metropolitan area networks Part 16: Air Interface for Broadband Wireless Access Systems”, IEEE, 2009.

[4] Ofuji, A. Morimoto, S. Abeta and M. Sawahashi, “Comparison ofPacket Scheduling Algorithms focusing on user throughput in highspeed downlink packet access”, Proc. of IEEE PIMRC’02, Vol. 3, pp.1462-1466, Sept. 2002.