

Comparison Of SINR In FemtoCell & MacroCell Network In MacroCell Environment

Kanak Raj Chaudhary¹, Rachna Arya²

¹BT-Kumaon Institute Of Technology, Dwarahat,
Uttarakhand Technical University, India
Department Of Electronics & Communication
kanakrajchaudhary@gmail.com

²Asst. Prof. In BT-Kumaon Institute Of Technology, Dwarahat,
Uttarakhand Technical University, India
Department Of Electronics & Communication
rachna009@gmail.com

Abstract: *Femtocells (HeNB) are deployed within macrocell coverage area to increase performance of indoor user. In order to cover, all indoor users, HeNBs make a network, known as femtocell network. Since, HeNBs use same spectrum, they are causing interference on both MeNB users (MUE) and among HeNB users (HUE). The performance of the femtocell network depends on the SINR of HUEs of respective HeNBs, which eventually depends on the interference produced on it. In order to improve the performance, we need to minimize the interferences among them. In this paper, we first study the SINR performance of HUEs in presence macrocell. We also analyze the outage probability in femtocell network. Finally, consider the power consumption of femtocell network.*

Keywords: Femtocell, Heterogeneous network, Outage probability, Interference, Power & SINR calibration.

1. Introduction

Femtocells are small mobile telecommunication network basestations using the customers' DSL or cable modem connections as backhaul. In addition, femtocells are self-configuring and do not require a professional for installation. The devices themselves are approximately of the same size as the current Wi-Fi access points. Many researchers have studied the femtocell business model, and simulated the performance and co-operation with the macro layer network. The femtocell specified in 3GPP standards, known as the Home NodeB, and other new components needed to integrate the solution with the current networks are presented together with the different possible deployment configurations. The radio spectrum is limited; therefore every now and then the developers have to come up with new solutions for the best efficient use of the spectrum. Various cell sizes like microcells, femtocells, picocells and nanocells are being used to increase the user capacity in urban areas like office buildings and shopping centers. Other method to improve coverage and capacity (2-3 folds) is by the use of distributed antenna systems (DAS) [1], which is an effective but expensive method.

2. Characteristics Of FemtoCell

A femtocell supports all major cellular standard protocols like GSM, CDMA, WCDMA, LTE, WiMAX, as well as all the protocols standardized by 3GPP, 3GPP2 and the IEEE/WiMAX forum [2].

- A femtocell base station works in a licensed spectrum which reserves the resources for only the subscribed users.
- The transmitting power of a HeNB is very small approximately around 0.1 Watts, thereby decreasing their coverage area as well. But due to this less coverage area, the signal quality i.e. coverage is excellent in its range.
- A HeNB is connected to the already existing cellular network via DSL lines or cables, using standard Internet protocols.
- The most significant feature of a HeNB is its plug n' play feature. This feature enables the end user or home user to install and start operating just by powering it on. No technical support is required.

3. Advantages Of Femtocells

- **Increased System Coverage and Capacity:** A femtocell offloads a macrocell's connections, which makes the macrocell's resources available for more users. This therefore increases the capacity as well as coverage [3].
- **Filling Coverage Holes:** Due to the limited transmission power, some portions inside the coverage area remain deficient of the optimal signal strength to make calls. Users within this area experience very poor signal quality and frequent call drops. A femtocell can be used to solve such purpose. It fills this area providing excellent signal quality such that call never drops.
- **Less Cost:** A macrocell base station's (MeNB's) cost set-up is huge in comparison to the HeNB cost set-up. So, instead of setting up a new MeNB site, several HeNB can be deployed in its place.
- **Energy Efficient:** As the distance between a femtocell user (HUE) and a femtocell base station HeNB is very less i.e. between 5m-20m, the battery consumption of the devices is far less than it was when the users were connected to the MeNB.

4. Different Access In Femtocell

The interference reduction is an important issue that needs to be addressed. Also, interference generally depends on the type of access control, which controls what kind of user can or cannot connect to the femtocell. The existing femtocell access methods for femtocells are [5]:

- **Closed Access:** Only the users subscribed to the respective femtocell can connect to its base station. These types of base stations are mainly deployed by the private owners. This type of access method leads to a high cross-tier interference. The Third Generation Partnership Project (3GPP) describes this model as a closed subscriber group (CSG).
- **Open Access:** If a femtocell is working in the open access mode, then all the users i.e. registered plus non-registered are able to access the femtocell resources. This makes every user connected to the femtocell at all times, getting the best QoS. One of the major disadvantages of this type of access mode is the increased number of handovers, and associated signaling overhead [6].
- **Hybrid Access:** A limited amount of femtocell resources are available to all users, while the rest are operated in a CSG manner.

5. Femtocell Applications

- **Femto- Intra-zone Services:** Automatic synchronization of music collection or pictures between the user's mobile phones and laptops/personal computer can be done when a user returns home [4].
- **Home Automation Services:** Mobile devices can be used to control home appliances like air conditioners, light switches, washing machines, etc. Virtual fridge notes can be delivered as soon as the user enters the home.

6. Energy Savings In Base Station

Due to increasing traffic demand, number of BSs have also increased, which is one of the biggest reasons of increase in greenhouse gases in today's time. This in turn also increases the network costs. The BSs alone contribute a carbon footprint of 11 tons of CO₂ [7]. Basically three elements constitute a typical cellular system- BSs, mobile terminals and a core network. With the increase in the number of BSs it becomes very important to address their energy consumption in a cellular network. Some basic methods to reduce energy consumption due to BSs are as follows:

- **Reducing BS Energy Usage:** Improving PA design can be one major way of energy saving. Also, EE can be increased by shutting down BSs during night times, when the traffic load is quite low in comparison to the day time. One more method is cell zooming, which includes the increase or decrease of the cell size according to the traffic load [8], [9]. Other than hardware design improvisation, methods like fresh-air cooling can be used in the place of air conditioners, which themselves consume a lot of power.
- **BS Cooperation:** Traffic load can significantly vary depending on numerous factors like mobility and environment. Traffic load is higher in office areas during daytime, and in residential areas during the night. This causes cells to have uneven distribution of traffic load. Therefore, a static cell size allocation is not apt for such kind of fluctuating traffic conditions. SON can be one of the ways to handle all the parameters [8]. About 20% of the energy can be saved by reducing the number of active cells having low traffic [9].
- **Use of Renewable Sources of Energy:** In countries like Northern Canada and Africa, cellular networks in remote areas operate on diesel operated generators, which is not only expensive, but also produces CO₂ gas. The

consumption of one such generator is about 1500 liters of diesel/month. In places like these renewable sources of energy like solar energy, biofuels and wind energy can be more viable to reduce the network operator cost.

A program called “Green Power for Mobile” has been set up by 25 telecom companies in the favor of use of renewable energy resources, joined under the Global Systems for Mobile communications Association (GSMA) [11]. This program was started with the aim of deploying renewable sources of energy to power BSs. But BSs like this are more expensive than the ordinary ones. However, technologies like this tend to get their payback within three years of their installation [12].

The outage or probability of successful reception in a femtocell network depends on a number of factors, like Channel State Information (CSI) [13], type of antenna used i.e. omnidirectional or directional [14], the distance between the BS and the UE [15], frequent reconfigurations [16], capacity regions [17], transmit power of the BS [18], and many more factors.

7. System Model

We have considered Femto base stations (HeNBs) having a transmission power of 0.1 Watts, located within a Macro base station network (MeNB) which has a transmission power of 16 Watts, as shown in Table-1. Figure-1 shows the typical scenario of femtocell base station deployment in a macrocell base station environment. Both types of base stations use the same frequency spectrum for downlink communication, which promotes the frequency reuse concept of the wireless system and thus decreasing the interference among adjacent users, and also increasing the spectral efficiency of the system. Since, the position of Macro users (MUEs) cannot be known (mainly due to mobility in their nature), we assume that only the MeNBs’ and HeNBs’ locations are known to us.

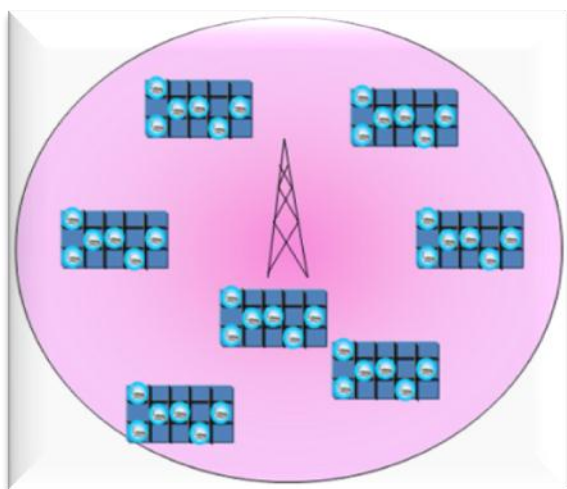


Figure-1. Typical scenario of femtocell deployment in macrocell environment.

Table-1 Simulation Parameters

Base Station	Range	Power
--------------	-------	-------

Macro	<2 Km	16 Watts
Femto	[1,3,6,8,10,13,16] m	0.1 Watts

8. Pathloss Modeling or 3GPP Model

There will be path loss between mobile user and corresponding base station. Path loss will increase as the distance between mobile user and corresponding base station increases. There will be two different formulas for calculating path loss, one for macro, base station and the other one for femto base stations. Since in case of femto base stations, wall penetration is also taken into consideration because indoor users will be assigned to femto base stations and there will be some additional losses in case of the indoor users.

Path loss formula for calculating path loss for macro base station is given as:

$$PL_{macro} = 10^{((PL_{cst} + PL_{gain} * \log_{10}(distance))/10)}$$

$$PL_{femto} = 10^{((PL_{cst} + PL_{gain} * \log_{10}(distance) + 0.7 * distance + wall_penetration)/10)}$$

$$PL_{Cst(femto)} = 137.74 \text{ \& } PL_{Gain(femto)} = 30$$

while

$$PL_{Cst(macro)} = 128.1 \text{ \& } PL_{Gain(macro)} = 37.6$$

Table-2. SNR comparison with MeNB connectivity and HeNB connectivity

User ID	SNR with Macro (dB)	SNR with Femto (dB)
1	1.3785	17.2140
5	1.5653	12.0936
7	1.5537	12.9801
8	3.7314	7.8451
9	3.7314	7.8451

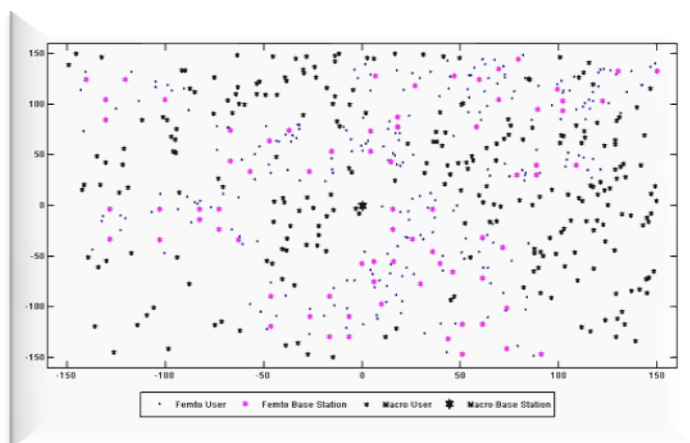


Figure-2. Matlab Scenario of implementation

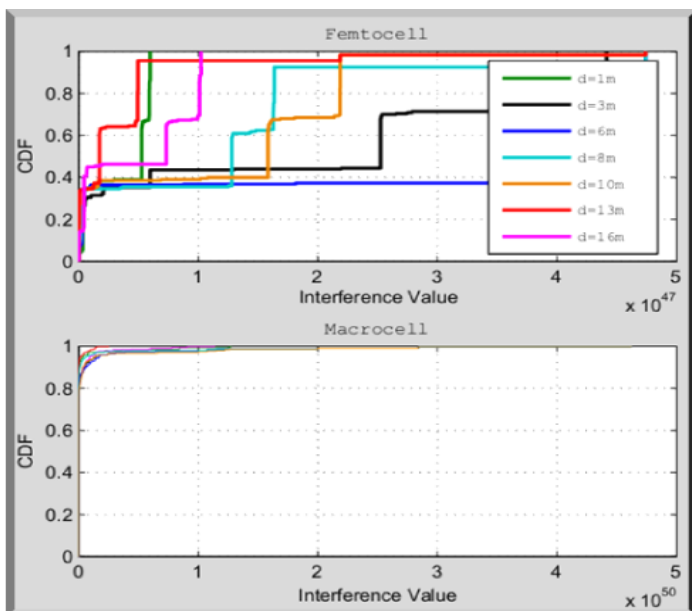


Figure-3. Matlab result Of SINR calibration

9. Conclusion

In this paper, I have presented the analysis of a heterogeneous wireless network consisting of femtocell and macrocell. In our analysis we assumed that the mobiles are connected to the nearest base stations. In this project we found an optimum combination of ranges for lowest interference for femtocell users. However, the ratio among heterogeneous femtocell base stations may play an important role on network spectral efficiency, capacity and many more performance factors. Radio resource management is technique through which we can increase the efficiency of the overall network. As we had seen in our analysis that deployment of femtocell reduces the power consumption and improve the coverage. In future if this technique is deployed efficiently then we can improve the performance of the in terms of power and coverage. In future we will work on the energy efficient deployment of femtocell in heterogeneous network so that our cellular system does not have any adverse effect on the environment.

References

- [1] Wan Choi and Jeffrey G. Andrews, "Downlink Performance and Capacity of Distributed Antenna Systems in a Multicell Environment", IEEE Transactions on Wireless Communications, 2007.
- [2] Vikram Chandrasekhar and Jeffrey G. Andrews, The University of Texas at Austin, Alan Gatherer, Texas Instrument, "Femtocell Networks: A Survey", 2008
- [3] Jeffrey G. Andrews, Holger Claussen, Mischa Dohler, Sundeep Rangan, Mark C. Reed, "Femtocells: Past, Present, and Future", IEEE Journal On Selected Areas In Communications, Vol. 30, No. 3, April 2012
- [4] Khaled Elleithy and Varun Rao, "Femto Cells: Current Status and Future Directions", International Journal of Next-Generation Networks (IJNGN) Vol.3, No.1, March 2011
- [5] Mustafa E. Şahin, Ismail Guvenc, Moo-Ryong Jeong, and Hüseyin Arslan, "Handling CCI and ICI in OFDMA Femtocell Networks Through Frequency Scheduling", IEEE Transactions on Consumer Electronics, Vol. 55, Issue 4, 2010
- [6] Rajarshi Mahapatra and Emilio Calvanese Strinati, "Radio Resource Management in Femtocell Downlink Exploiting Location Information", IEEE International Conference on Advanced Networks and Telecommunication Systems, 2011
- [7] J. T. Louhi, "Energy efficiency of modern cellular base stations," 29th International Telecommunications Energy Conference (INTELEC), 2007, pp.475-476, Sept. 30 2007-Oct. 4 2007.
- [8] Zhisheng Niu, Yiqun Wu, Jie Gong, and Zexi Yang, "Cell zooming for cost-efficient green cellular networks," IEEE Communications Magazine, vol.48, no.11, pp.74-79, November 2010.
- [9] M. A. Marsan, and M. Meo, "Energy efficient wireless Internet access with cooperative cellular networks," Comput. Networks, 2010.
- [10] M. A. Marsan, L. Chiaraviglio, D. Ciullo, and M. Meo "Optimal Energy Savings in Cellular Access Networks," IEEE International Conference on Communications Workshops, 2009, pp.1-5, 14-18 June 2009
- [11] "The Mobile Economy 2013", <http://www.gsmworld.com/our-work/mobileplanet/green-power-for-mobile>, Retrieved April 24, 2013
- [12] "Bi-annual Report November 2010", Green Power for Mobile, GSMA. Available: http://www.gsm.org/documents/GPM_Bi-AnnualReportJune10.pdf, Retrieved May 1, 2013
- [13] Salam Akoum, Marios Kountouris, Robert W. Heath Jr., "On Impact CSI for the Downlink of a Two-Tier Network", ISIT, 2011
- [14] Vikram Chandrasekhar and Jeffrey G. Andrews, "Uplink Capacity and Interference Avoidance for Two-Tier Femtocell Networks", IEEE TRANSACTIONS ON

[15] Giulia Fanti and Kangwook Lee, "Femtocell Networks", 2012

[16] Wei Wang, Jin Zhang, Qian Zhang, "LOGA: Local Grouping Architecture for Self-Healing Femtocell Networks", Wireless Networking Symposium, Globecom, 2012

[17] VenkateshRamaswamy and Deepak Das, "Multi-Carrier Macrocell Femtocell Deployment—A Reverse Link Capacity Analysis", Vehicular Technology Conference Fall, 2009

[18] Chuan Huang, Rui Zhang, Shuguang Cui, "Outage Minimization in Fading Channels: Optimal Power Allocation with Channel Distribution Information Known at Transmitter, Communication Theory Symposium2215, Globecom 2012



(1) **Kanak Raj Chaudhary** received his B.Tech. degree in Electronics and Communication Engineering from Uttar Pradesh Technical University, Lucknow in 2009. Presently he is pursuing M.Tech. from BTKIT Dwarahat, Almora, Uttarakhand. His area of interest includes Wireless Communication, Digital Communication.



(2) **Mrs. Rachna Arya** received her M.Tech. degree in Digital Communication Engineering from Uttarakhand Technical University, dehradun in 2012. Presently she is Assistant Professor BTKIT Dwarahat, Almora, Uttarakhand. She has job experience of 9 years.

Author Profile