# Suppression of Interference in Femtocell Networks using OSR-Sleep Mode

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**Abstract**
*One of the important techniques to improve the cellular coverage, capacity and data rate is to reduce the size of cellular cell and the distance between the transmitter and the receiver. The concept of femtocell starts with this need. Studies show that 70% of data traffic originates indoor and 50% voice traffic is also indoor. The deployment of femtocell fulfills all the requirements of data rate and coverage. But, in macro-femto deployment, same spectrum of macrocell and femtocell causes interference. So, this paper basically proposes an approach that how interference is reduced in macro-femto deployment. It proposes a concept of OSR in sleep mode of femtocell. It also proposes an algorithm for coverage enhancement based on OSR for a given area. Assuming that parameters of neighboring femtocells are known, the parameter of OSR is introduced to represent the whole impact of neighboring femtocells. Subsequently, the relationship between the OSR and rotation angle is quantized by algebraic equation, which guarantees that the node with larger overlapping region would turn greater rotation angle. This concept improves SINR for both MUEs and HUEs.*

**Keywords**
*OSR, femtocell, interference mitigation, two-tier network.*

## I. Introduction

In wireless communication, there is tremendous increase in indoor voice and data. It is a challenge for the operators to overcome the in-building coverage problems. So, femtocell is a new technology that can offer improved indoor coverage, and also voice and broadband services at very low cost. Femtocells are small, low power, short range base stations designed typically for home or small business enterprise and it communicates in licensed spectrum. It is connected between service provider's network through broadband (DSL or cable). It is currently designed to accommodate 4 to 8 mobile in residential areas and 16 in enterprise. Femtocell allows the service providers to extend its services for e.g. at the cell edge the mobile phone is enable to receive a signal from macrocell network, at that time femtocell can provide coverage. There are several advantages of using femtocell first: it can fill in the gaps and also loss of signal is eliminated, second it can be used to offload the traffic from macrocell to the femtocell network. In other words it can be said that in place of operator's private network the internet is used, third is improved battery life.

Femtocell is an alternative way to deliver the advantages of Fixed Mobile Convergence. It can save upto 69% spectrum in a cell area [1]. There is a difference between most FMC architectures which require new handset and works in unlicensed spectrum while femtocell does not require new handset and works in licensed spectrum. In Third Generation Partnership Project (3GPP), Home Node B (HNB) is a 3G femtocell and Home evolved Node B (HeNB) is a LTE 4G femtocell. There is reduction in site built cost because of lower network capital architecture in case of femtocell as discussed in [2]. But, when femtocells are deployed densely, there are several technical problems which occur. First, interference, as both the macrocell and the femtocell is using the same spectrum. A Macro User Equipment (MUE) in the downlink can suffer co-channel interference due to different nearby femtocells causing path loss and shadowing effects [3]. Femtocell are low power base station but in dense deployment of femtocell the overall energy consumption of the network is increased.

There are several techniques such as cell zooming and sleep mode which can reduce the overall total energy consumption of the network [4]. The several effects on the network energy efficiency of a joint macro and femto cell deployment has been investigated in [5]. In paper [6], the issue of power consumption is solved by using a novel strategy which allows the femtocell base station (BS) to switch off the radio transmissions and associated processing when it is not involved in an active call. As, we already know that dense deployment causes increase in overall cost of network, in paper [7] they introduced the concept of energy efficient sleep mode algorithms, it allows the switching off of its hardware components. There are basically three types of sleep mode algorithms first is small cell based, core network based and user equipment based. The algorithms have saved upto 10-60% energy in the network when it works in sleep mode. Jian Chen et.al [8] have proposed a coverage enhancing algorithm based on overlap sense ratio. By adjusting the sensing direction of the nodes, the coverage area has been increased with the reduction of computational complexity. In a paper [9] they have discussed the sleep mode activation algorithm for co-tier and cross-tier interference mitigation

The rest of the paper organized in this manner: section 2 consist of system model in which different path loss models are described, section 3 gives the proposed model for interference mitigation, section 4 presents the results and analysis and section 5 is the conclusion

## II. System model

With the deployment of femtocells in the macrocell network, some changes would be needed in the conventional macrocellular network. The new architecture consists of two layers, femtocell layer and macrocell layer and it is called two-tier or two level network. The system model is taken to study the impact of interference on the performance of MUEs and home user equipments (HUEs), and there are four performance parameters first is signal to interference plus noise ratio (SINR), the number of blocked MUEs , power consumption by femtocell due to the introduction of the sleep mode-overlap sense ratio for femtocell base stations. The new architecture of two-tier network brings new problems and design challenges.

### A. Interference Scenario

In simple telecommunication system, when different transmitters

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transmits signal in the same frequency band, the receiver will not be able to distinguish that which signal is coming from which transmitter. The same problem arises in femtocell, and there are two types of interference in two tier network first is co-tier interference and second is cross tier interference. In co-tier interference, when a femtocell receives unwanted signal from other femtocell this causes interference in the received signal. It occurs mainly due to low isolation between apartments and houses. It is independent of macrocell layer. But, in cross tier interference both femtocell and the macrocell have the same frequency band, this causes interference in received signal in both uplink and downlink. Spectrum splitting is used to cope with the problem of cross-tier interference.

### B. Path Loss Models and SINR Calculations:

In this paper, the 3GPP LTE-A path loss models [10] for urban deployment has been taken i.e. Indoor femto Channel model : Urban deployment:

Case 1: UE to Macro BS:

(a) When UE is outside, then Path loss is given by Eqn.1

$$PL(dB) = 15.3 + 37.6 \log_{10} R \quad (1)$$

(b) When UE is inside an apartment, then the Path loss is given by Eqn.2:

$$PL(dB) = 15.3 + 37.46 \log_{10} R + L_{ow} \quad (2)$$

Case 2: UE to HeNB:

(a) When UE is inside the same apartment stripe as HeNB, then the path loss is given by Eqn3:

$$PL = 38.46 + 20 \log_{10} R + 0.7 d_{2D,indoor} + 18.3^{\left((n+2)/(n+1)-0.46\right)} + q^{*} L_{iw} \quad (3)$$

(b) When UE is outside the apartment stripe, then the path loss given by Eqn.4:

$$PL(dB) = \max(15.3 + 37.6 \log_{10} R\ ,\ 38.46 + 20 \log_{10} R) + 0.7 d_{2D,indoor} + 18.3 n^{((n+2)/(n+1)-0.46)} + q^{*} L_{iw} + L_{ow} \quad (4)$$

Where R is the distance between the transmitter and receiver in meters, $L_{ow}$ is the penetration loss of outdoor wall, $d_{2D,indoor}$ takes account of penetration loss due to walls inside an apartment, q is the number of walls separating apartments between UE and HeNB , $L_{iw}$ is the penetration loss of the wall separating apartments, which is 5dB and n is the number of penetrated floors. Table 1 shows the simulation parameters taken in overlap sense ratio-sleep mode algorithm.

Table 1 : Simulation Parameters

| Parameters | Macrocell | Femtocell |
|---|---|---|
| Cell radius | 500 m | 10m |
| HeNB transmitter power | 46dB | 20 dB |
| HeNB antenna gain | 14dBi | 5dBi |
| Log normal shading SD | 8dB | 10dB |
| Carrier frequency | 2.0GHz | |
| Bandwidth | 10MHz | |
| Antenna pattern | Omnidirectional | |
| Thermal noise | -174dBm/Hz | |

## III. Proposed Model for Interference Suppression

In this paper, only downlink scenario is only considered, as shown in Fig.1, eNB (evolved NodeB) is assumed to be in the centre of the cell. A grid of 5×5 of dense urban area is considered, in which there are 25 rooms and each house has the size of 10m×10m. The grid is located at the edge of the macrocell. In the twenty rooms HeNBs are dropped randomly in the houses and only cell edge users are considered in the simulation as they are more prone to interference. We assumed that femtocell or HeNB exists in only one of the following states i.e. either in active state or sleep state. In active state, all the HeNBs are switched ON and provide coverage to allowed users, while in sleep some of the HeNBs are completely switched off.

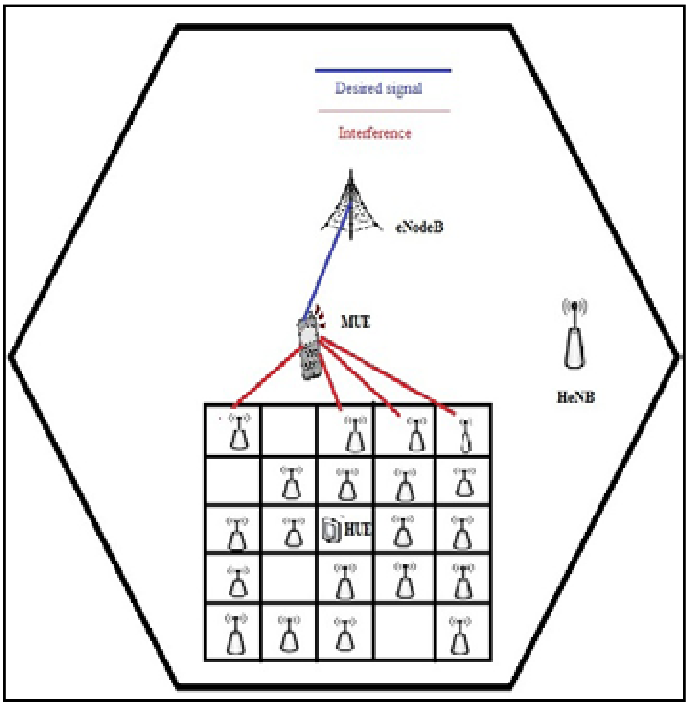


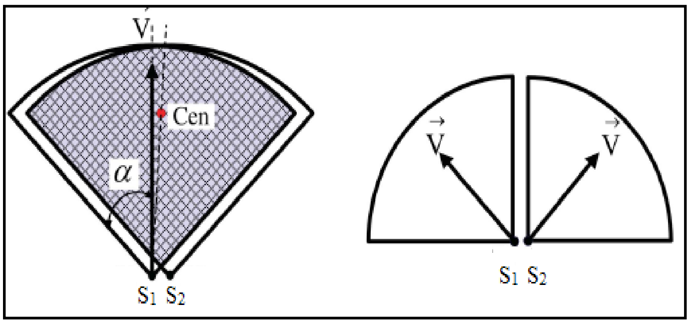

Fig.1 : Interference scenario in macro-femto deployment.

### A. Overlap Sense Ratio-Sleep mode activation algorithm

Since, different femtocells transmit energy at the same time in active state, this causes interference from one another, in other words it can be said that there is overlapping of coverage. The objective of the proposed algorithms is to reduce the overlapping region and cover the dead zones or sensing blanks as much as possible. The parameter OSR, is the ratio of overlapping area to the sensing area and it is given by Eqn.5,

$$\eta = \frac{M_2}{M_1} \quad (5)$$

where, $M_1 = \alpha R^2$ is the sensing area and $M_2$ is the overlapping area. OSR varies from 0 to 1 and there is a relation between OSR and the rotation angle. When □=1, the node will adjust its direction with the maximum rotation to reduce the overlapping region This case is shown in Fig.2 (a), where sensing region of $S_1$ is almost covered by $S_2$, and $S_1$ should counterclockwise rotate with the angle of α. Similarly, $S_2$ should clockwise rotate with the same angle. The result is that there is no overlapping region between $S_1$ and $S_2$, which is shown in Fig.2 (b). The other case is that there is no overlapping region which means η = 0 so it is unnecessary to adjust sensing direction, i.e. the rotation angle of node is 0.and when □=0, then the rotation angle is also 0.




(a) (b)

Fig.2 : Adjustment of sensing direction when η =1

Firstly, in this paper different SINR values are calculated according to different path loss models, in which the concept of OSR is introduced in the transmitter side. After calculating the values of different SINR, for each SINR its probability is calculated. In the research work the concept of OSR is used which increases the probability at even lower SINR values. So, in the research work the probability of getting even weaker signals is improved.

## IV. Results and Analysis

There is one parameter which is improved, i.e, Average MUE SINR in which by introducing the concept of Overlap Sense Ratio, there is tremendous amount of increase in probability of SINR at lower thresholds. As shown in Fig.3, at -5dB the probability is 0.1 for sleep mode and 0.26 for SM-OSR (sleep mode-OSR), it means there is improvement in probability by 0.16. Table 2 gives the comparison between the probability of Average MUE SINR for sleep mode and SM-OSR .

Table 2 : Average MUE SINR for sleep mode and SM-OSR

| Parameter | Sleep Mode | | SM-OSR |
|---|---|---|---|
| | SINR(dB) | Probability | Probability |
| Average MUE SINR | -10 | 0 | 0.1 |
| | -5 | 0.1 | 0.26 |
| | 0 | 0.42 | 0.48 |
| | 5 | 0.67 | 0.69 |
| | 10 | 0.83 | 0.83 |

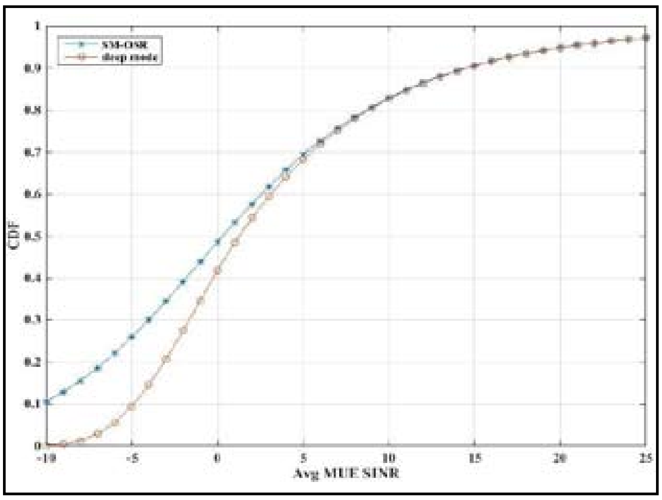



Fig.3 : Average MUE SINR.

## V. Conclusion

The growth of femtocells within macrocells brings new opportunities and challenges for the wireless network operators. In co-tier deployment scenarios, femtocells will cause interference to macrocells. This effect will be severe for cell-edge MUEs. By using the concept of OSR in the sleep mode the interference is reduced for both HUE and MUE.

## References

[1] *P.K.Chopra, S Jain and Venugopal Dasraju , 2011, Mobile Bandwidth saving estimate model using FMC, Asian Journal of Information Technology, pp.154-164.*

[2] *Lin P, Zhang J, Chen Y, Zhang Q. Macro-femto heterogeneous network deployment and management: from business models to technical solutions. IEEE Trasactions Wireless Communication 2011, pp.64-70.*

[3] *Saquib N, Hossian E, Lee LB, Kim D I, Interference management in OFDMA femtocell networks: issues and approaches. IEEE Wireless Communication Magazine 2012, pp.86-95.*

[4] *Claussen H, Ho LTW, Dynamic idle mode procedures for femtocells. Bell Labs Tech. J 2010, pp.95-116.*

[5] *Cao F, Fan Z, The tradeoff between energy efficiency and system performance of femtocell deployment. In: Proceedings of ISWCS; 2010, pp.315-319.*

[6] *Ashraf I, Ho, LTW, Claussen H, Improving energy efficiency of femtocell base stations via user activity detection. In: Proceedings of WCNC,2010.pp. 1-5.*

[7] *Ashraf I, Boccardi F, Ho L. Sleep mode techniques for small cell deployments. IEEE Communication Magazine 2011, pp.72-79.*

[8] *Jian Chen, Lu Zhang, and Yonghong Kuo, 2013, Coverage-Enhancing Algorithm Based on Overlap-Sense Ratio in Wireless Multimedia Sensor Networks, IEEE Sensors Journal, Vol.13, No.6, pp.2077-2083.*

[9] *Sam John, Joju George Sajan, D.Barath, K.Vinoth Babu and M.Arthi, 2015, Interference mitigation in two tier femto networks with sleep mode activation, IEEE ICCSP 2015 conference, pp.267-269*

[10] *3GPP TR 36.814. Evolved Universal Terrestrial Radio Access (E-UTRA); further advancements for E-UTRA physical layer aspects. March 2010.*

## Author's Profile

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