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Power and Coverage Based Performance Analysis for Femtocells Network

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ABSTRACT

The study of mobile communication/ cellular network in the industry of telecommunication is the fast-growing technology of this era. Demands of higher data rates in the indoor environment is increasing day by day. To achieve this demand femtocells are the best option for indoor environment. In the coming future, Femtocell is most important and best case for low power and low-cost base stations for indoor users. It is widely acceptable that by providing better quality in indoor environment, there will be a great revenue for cellular operator. This paper presents coverage and power analysis of femtocell network in indoor environment. For this purpose, different scenarios for indoor environment are analyzed by randomly deployed base station and users. The simulation results show that it covers the maximum number of users with low power while using minimum number of base stations.

Keywords: *Femtocell; Coverage; Power; Indoor; Optimization;*

1. INTRODUCTION

The study of 3G services in this century has provided a new dimension in the industry of telecommunication for the users. The vision is to merge both internet and mobile services for higher data rates and quality via mobile device. In telecommunication, a Femtocell is a low power, low cost, and small efficient home base station. Which typically provides services to 4-5 users within the range of 10 to 15m without any data losses. A broader term which is more whispered in the industry is that Femtocell is a subset and it is also known as Femtocell Access Point. Femtocell Access Point (FAP) connect users through Optical Fiber and Broadband connection with the Telecom Core Network. Another most important function of Femtocell is it gives limited access to the users because it operates in the Closed Subscriber Group (CSG). Keeping this in mind to overwhelmed the indoor challenges posed by Small Cell.

Femtocell base station is most important in the case for indoor users because coming future in telecom industry is for indoor users. It is widely acceptable that by providing better quality in indoor environment, there will be a great revenue for cellular operator and it also increases the network Capacity Performance. According to the survey [1] more than 60% of voice calls and 90% of data traffic is originated indoors. Around 2005 [2], the term femtocell was adopted for a standalone, self-configuring home base station, higher capacity. Year upon year service providers struggle to plan for subscriber growth increasingly indoor user over the years is shown in Fig1. In order to achieve the goal, service providers analyze various cell site for development in the highly-congested area to reduce the inter site distance by providing micro and even Pico cell services.

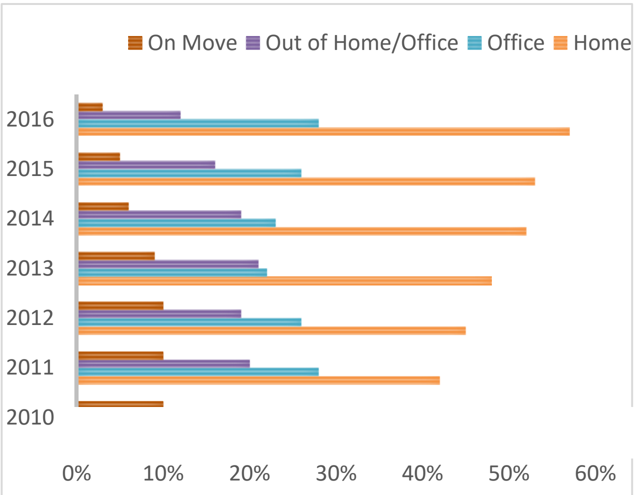

Figure 1 Increasingly Indoor User Over the Years

The major fact in planning a cellular system is the path losses and wall losses and this create difficulty in supporting data or measurement. Due to the prorogation path losses of the outer walls premises as well as inner floor loss, providing better coverage in an indoor environment is a difficult task. In this paper, the coverage and power analysis for femtocell network will be analyzed in different scenarios and the proposed model give surety to provide sufficient services and use of low power. The obtained analytical results are verified through our simulation.

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2.LITERATURE REVIEW

There is a growing body of research on femtocells, some previous work is briefly summarized and discussed early results here. Technical challenges from the perspective of technology and business that consist of broadband, voice, and infrastructure for femtocell network. The research gives preliminary ideas for providing a low-cost solution by V. Chandrasekhar and Jeffrey G. Andrews [3].

Coverage coordination scheme based on self-configuration and self-optimization of transmit power. An analytical expression introduced for coverage leakage of the femtocell is derived and verified using the simulation tool. This simulation shows that the proposed solution provides sufficient indoor coverage and low coverage leakage to outdoor areas by H. S Jo [4].

J G Andrew et al [5] work on the survival of femtocell in the industry, does femtocells be vital for unburdening data and video from the outdated network or not. The present research is based on study of femtocell network past, present and future. The authors justify their goal theoretically by conducting a survey. L Mohjazi et al [6] presented an experimental approach based on the genetic algorithm to automatically optimize the coverage of a group of femtocells in an enterprise environment. The results demonstrate the ability of the algorithm to dynamically update the pilot power of femtocells.

The algorithm is assumed to work with any air interference. T Priebe [7] has given an overview about current techniques and research in Femtocells. Interference management will have discussed in first part of paper and in second part of paper handover is discussed when a user leaves a Wi-Fi network and enter into a microcell, O.A Akinlabi et al [8] work based on the literatures. Their research work focuses on the different types of femtocell and also discuss the interference management. Researcher have provided different kinds of method to deal with interference problem in femtocell network like interference cancellation and interference avoidance. Shu-ping Yeh et al [9] presented a model in this article and consider a WiMAX network for which the proposed system performs deploying for both Macro base station and Femto base station, and the FAPs operate on the same frequency band as Macro BS.

Simulation results show that substantial areal capacity and gain can be attained via intense spatial recycle of the wireless spectrum. Rahul Thakur et al [10] introduce the concept of cell biasing for femtocells to improve the process of user overtone and resource consumption. Their research work evaluates the effects of cell biasing on femtocell cellular network and delivers improvement in capacity and energy efficiency of the network through frequency reprocess and subchannel power control.

3. SIMULATION PARAMETERS AND MODEL

The process consists of many stages but the main part is to design the layout of building and rooms by using idle dimensions shown in Fig 2.

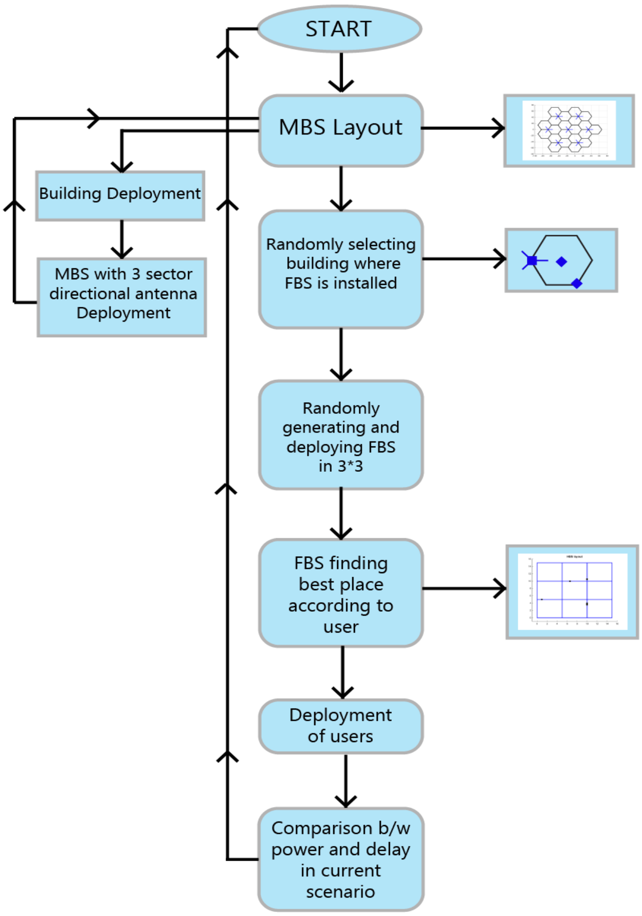

Figure 2 Simulation Model

First thing is the design layout for Macro Base Station (MBS), next step is the important parameter plan for grid model of floors and rooms, in which the deployment of FBS and random drop-offs of FBS according to the moving users on floor is performed, [11] the end and complete model result is shown in Fig 3. For creating and simulating model MATLAB standard tool is used. Here the present work delivers some updates on the simulation hypothesis and parameters according to our study and previous research.

In outdoor parameters, inter-site distance between the microcell which is 500nm to 1732nm created and the number of rings is 1, height is 5m, Microcell user equipment distance from base station 1m. Building Model, standard size of each apartment would be 3m x 3m. There is a corridor between each apartment having width of 5m. The attenuation values will be given to our scenario in which the outer wall attenuation can be fixed to 2dBm and floor attenuation will be set to 1.3 dBm.

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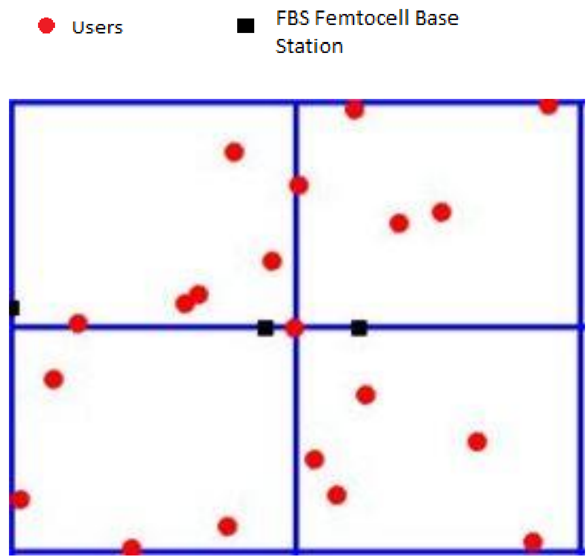

Figure 3 HBS / FBS Layout

HeNB in the Macro coverage area is dropped by using random uniform distribution with transmitting power of 5dbm. If once the femtocell base station is dropped in the coverage area assumed to be active, within each office or floor the HeNB and HeNB user equipment is dropped randomly within the quantified distance from the center point of the office. In order to evaluate the performance of the communication between sender and receiver the important thing is to find the SINR, having K with the power P is expressed below in equation 1.

$$SINR = \frac{P_{mk}\ G_{mk}}{N_o + \sum_M P_{km}\, G_{km} + \sum_F P_{Fk}\, G_{Fk}} \ldots..(\mathbf{1})$$

Where $\boldsymbol{P_{mk}}$ is the Power transmission from the base station, $\boldsymbol{G_{mk}}$ is the Gain of channel, $\boldsymbol{N_o}$ is the white noise power, $\boldsymbol{P_{Fk}}$ is the Power transmission from the FAP, $\boldsymbol{G_{Fk}}$ is the gain from the FAP.The azimuth antenna pattern for Macro is modeled as mentioned below in equation 2:

$$A(\theta) = -\min\left[12\left\{\frac{\theta}{\theta_{3dB}}\right\}^2, A_m\right] \ldots..(2)$$

Where θ_{3dB}= 70 degrees and Am=20dB. The path loss model is compute in the simulation for different situation.

For Outdoor Path Loss Model:

When a UE is outside and inside the home, the signal generated from user to Macro base station and during the transmission signal strength is reduced due to travelling from any obstruction in the environment is mentioned in equation (3).

$$PL(dB) = 15.3 + 37.6 * \log 10\ (D_i) + (A_i) \ldots..(3)$$

For Indoor Path Loss Model:

When a UE is outside the home, the signal generated from user to Femto base station and during the transmission the signal strength is reduced due to travelling from outer environment and walls, the indoor PLM for mathematical computation is mentioned in equation 4.

$$PL(dB) = 38.46 + 20 * \log 10\ (D_{i1}) + 0.7 * (D_{i2}) + (A_i) \ldots..(4)$$

For Outdoor UE to indoor BS Path Loss Model:

When a UE is outside the home, the signal generated from user to Femto base station and during the transmission the signal strength is reduced due to travelling from outer environment and walls. Mathematical form of loss is mention below in equation 5.

$$PL(dB) = max\big(15.3 + 37.6 * \log 10\ (D_i) + (A_i)\big) * (38.46 + 20 * log * \big(38.46 + 20 * \log 10\ (D_{i1}) + 0.7 * (D_{i2}) + (A_i)\big). \ldots.(5)$$

Where PLis the Path Loss Model for both three models. D_i is the distance between indoor wall. A_i is the Indoor attenuation between walls.

Total wall attenuation of both thick and thin walls in [12] indoor environment between the transmission from user to base station or vice versa is demonstrate in equation (6).

$$W_a(dBm) = TB_{f1} * IW_a(2) + TB_{f2} * IW_a(1) + 2 * OW_a \ldots..(6)$$

Where W_a is the Wall Attenuation TB_f= $4^{(M-1)}$ is the Transmit Beforming in which M=1 and M-1 means it is less than the total number of FBS antennas because M is the total number of FBS antennas. IW_a/OW_a is the Indoor and Outdoor Wall Attenuation between walls which is equal to 10dB or 20dB.The link level performance is approached [13] by using the SINR-throughput plotting given as follows in equation 7.

$$TP\ (dB) = \min\big(BW * BW_{eff} * \log 2(1 + \max(SINR)/(SNR_{eff}\big) * TP_{max} \ldots \ldots (7)$$

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$$BW_{eff} = 0.56/0.62/0.66 \ for \ SISO/SIMO/MIMO \dots \dots (7.1)$$

$$SNR_{eff} = 2.0/1.8/1.1 \ for \ SISO/SIMO/MIMO \dots \dots \dots (7.2)$$

$$TP_{max} = 4.1 , SINR_{min} = -10dB \dots \dots \dots \dots \dots \dots \dots \dots (7.3)$$

TP is the transmitting power of the transmitted signal BW being the bandwidth, SINR is signal to interference plus noise ratio, and now the antenna type for propagation is SISO is single input single output, SIMO single input multiple output, MIMO is multiple input and multiple output.

4. SIMULATION RESULTS AND DISCUSSION

The proposed model assumed that there is [14] at most one HBS per flat. Each row represents to a single Home Base Station and we assumed that each HBS is installed on the wall of the office which is shown below in Fig 4.

If a drop-off is fixed, then the number of base station in each office is fixed and same on all other offices. The number User Equipment is multiplied by the number of offices. All UEs dropped successfully is in active mode.

If drop-off is stat, then the User Equipment is dropped and scattered uniformly in each office of the building and the possibility of each drop is active and there is a maximum possibility that they are in active mode.

If drop-off is spec, then the function will receive the number of UEs index and the number of UE position in each flat and that save the active drops position and if there is an in active base station and that replaced by the active base station.

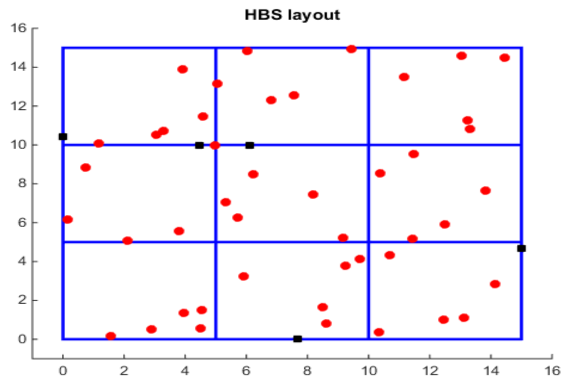

Figure 5 Final Deployment of Home Base Station

Next are the results for optimized power in which we have delay in Nano seconds and power for Micro Base Station of 6 dBm and for Femtocell Base Station we use 5dBm with the diversity gain of 3dB, then the relation of power and delay in current scenario is simulated and shown in Fig.5

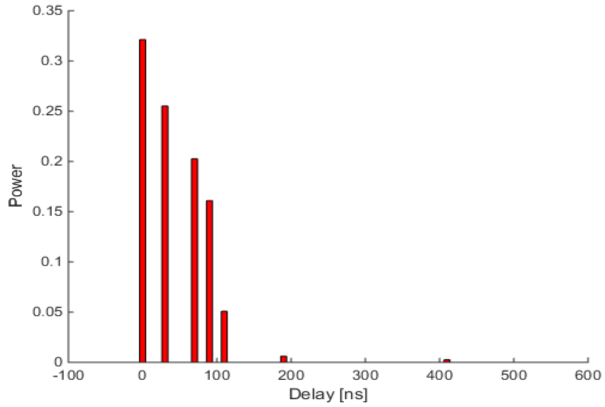

Figure 6 Relation Between Power and Delay

If we have a delay of zero Nano seconds, then the power will have reached to its maximum. In communication, the delay at the time of transmission is approximately zero but the moment when signal reaches the medium delay again come into business and the signal become weak again as it reaches to the user. Downlink Comparison for indoor environment is presented in Fig.6.

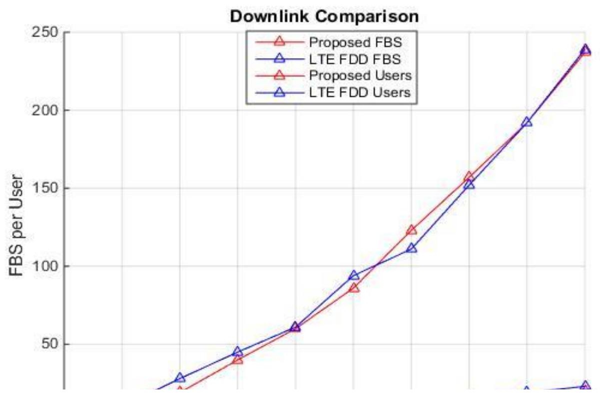

Figure 4 A Comparison between LTE FDD Model and New Downlink Model

The above mention figure validates the comparison between proposed model and LTE FDD model. We improved our result in reducing the number of base station and also increase the number of user by utilizing a minimum number of FBS. Uplink Comparison for indoor environment is presented in Fig.7.

It can be shown in Figure 6 ,7 we achieved maximum of our goals and our results demonstrate that the proposed model optimized the power, also reduce the number base station and cover maximum users.

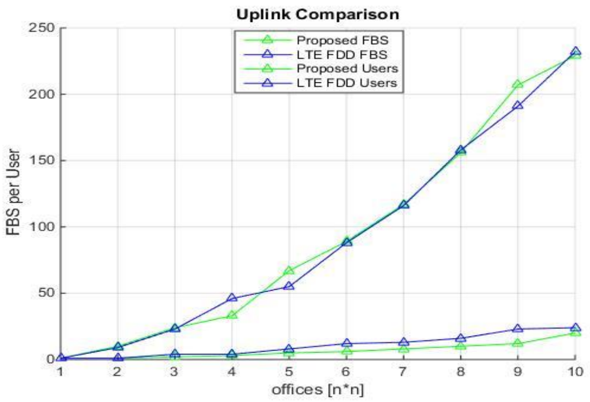

Figure 7 A Comparison between LTE FDD Model and Proposed Uplink Mode

5. CONCLUSION

This research work concludes that the cellular industry has bright future in the coming few years and Femtocell base station is the accurate and best option for achieving higher data rates. As the demand of higher data rates, resolving coverage problem is important now days otherwise this issue can lower the user experience. An approach based on optimization is presented in this paper for Femtocell network. The results show the ability of optimized model for Femtocell Network. In our research work we achieved the optimized value for power, number of base station, and better coverage in indoor environment.

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