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RESEARCH ARTICLE

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ANALYSIS OF PROPAGATION PATHLOSS MODELS AND THROUGHPUT FOR MACRO CELLS IN PRESENCE OF FEMTO CELLS

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ABSTRACT

This work studies about the propagation path loss models for macro cells by considering different cases for user equipment position with respect to macro cell position and estimating about throughput in each case.A macrocell is a cell in a mobile phone network that provides radio coverage served by a high power cellular base station (tower). The antennas for macrocells are mounted on ground-based masts, rooftops and other existing structures, at a height that provides a clear view over the surrounding buildings and terrain. A femtocell is a wireless access point that improves cellular reception inside a home or office building. The device, which resembles a wireless router, essentially acts as a repeater. The device communicates with the mobile phone and converts voice calls into voice over IP (VoIP) packets. However, femto cell is deployed to improve cellular reception but it also causes interference to macro signals.

Keyword: Macro cell; Femto cell; Pathloss models; Throughput; Simulation framework.

I.INTRODUCTION

Mobile cellular communications revolutionized in communication system applications. The present mobile cellular communication networks normally often suffer from poor penetration and reception in certain areas, like indoor and apartments in turn decreasing quality of service [1].A heterogeneous network is a network connecting computers and other devices with different operating systems and/or protocols. Heterogeneous network is also used in wireless networks using different access technologies. For example, a wireless network which provides a service through a wireless LAN and is able to maintain the service when switching to a cellular network is called a wireless heterogeneous network[2].

The Heterogeneous Network terminology may have different connotations in wireless telecommunications. For instance, it may refer to the paradigm of seamless and ubiquitous interoperability between various multi-coverage protocols (a.k.a. Het Net). Otherwise, it may refer to the non-uniform spatial distribution of users or wireless nodes (a.k.a. Spatial In homogeneity). Therefore, using the term "heterogeneous network" without putting it into perspective may result in a

source of confusion in scientific literature and during the peer-review cycle. In fact, the confusion may further be aggravated, especially in light of the fact that the "HetNet" paradigm may also be researched from a "geometrical" angle .HetNet often indicates the use of multiple types of access nodes in a wireless network[3].

Macro cells can be regarded as cells where the base station antenna is installed on a mast or larger building structures that are taller than an average roof-top level. The user capacity of cellular networks can be increased by reducing cellsizes currently stimulates the development of micro- and pico- cellular networks. Inmacro-cellular networks cell sizes usually range from 1 to 20 km. [4]A Wide Area Network can use macrocells, picocells, and/or femtocells in order to offer wireless coverage in an environment with a wide variety of wireless coverage zones, ranging from an open outdoor environment to office buildings, homes, and underground areas [5].

Femtocell can be used to improve wireless coverage over a small area, especially in indoor and urban environment. Femtocell is a small cellular base station that connects to a broadband Internet connection. The major technical challenges of femtocells are cross-tier, Intra-tier and user equipment interference, quality of service, handover operation and spectral accuracy. The predominate issue is cross-tier interference constituting macro cell and femtocell networks constitutes the greater portion of interference in terms of adjacent channel interference [1].

II. **Pathloss in Macro Cell**

A macrocell provides the largest area of coverage within a mobile network. The antennas for macrocells can be mounted on ground-based masts, rooftops or other existing structures. They must be positioned at a height that is not obstructed by terrain or buildings. Macrocells provide radio coverage over varying distances depending on the frequency used, the number of calls made and the physical terrain. Macrocell base stations have a typical power output in tens of watts.[6]

Path Loss is the attenuation that occurs as the voice travel over a distance or through obstacles. For example, if a speaker is loud enough that the attenuation of the sound allows the listener to hear and understand, then, communication is successful. Path Loss occurs naturally with distance and obstacle between the transmitter and receiver also attenuate signal. The application of femtocell provides a good quality of service (QoS) and high performance. Figure 1 shows the path loss within the transmitter and receiver channel. Generally, whenever the received signal strength is poor, it is required to use the femtocell as signal booster's receiver. Since most of the calls mainly originate from the indoor environment, this makes femtocell more important for indoor uses but also causes cross tier interference[7].

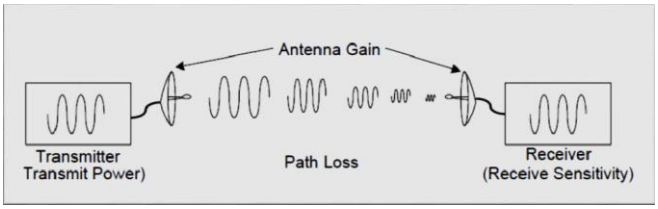

Fig 1: Show the direction of path loss between the transmitter and receiver. [7]

III. Interference between macrocell and femtocell

The current situation in most cellular networks is that in city centers, the conventional size cells, often called macrocells, are small, i.e., only 500 m to 2 km across. However, the base station antennas are usually on the roofs of tall buildings. Single microcells, rather than clusters of them, are being introduced to accommodate teletraffic hot-spots. The microcellular base station antennas are usually located at some 6–9-m height and attached to walls or mounted on the roofs of low buildings. The operators appreciate that eventually the isolated microcells will be expanded into clusters and the microcellular clusters tessellated. Macrocellular sectors will oversail the microcellular clusters, providing coverage in microcellular radio dead-spots, and assisting handovers when candidate microcells have no available channels [8]. Wang et

al. [9] propose a novel way to share spectrum by rotating the sectors of the macrocells in adjacent clusters, enabling a number of co-channel microcells to work in reduced interference microareas.

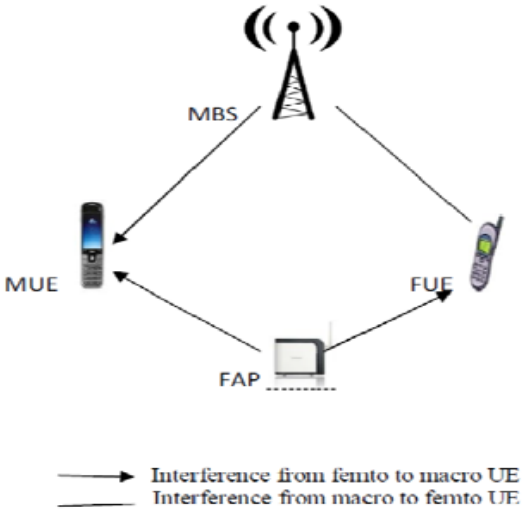

Fig 2: Typical cross tier interference between femtocell and macrocell.

Interference in cross tier occurs between different network elements. For example, the unwanted signals by FAP cause interference to downlink of macrocell users and likewise the unwanted signal by macrocell user at the uplink cause interference to FAP user.This is cross tier interference to both network systems. Thecross tier interference is more sever in CDMA co- channel deployment due to the reason that both femtocell and macrocell make use the same frequency band. The figure below illustrate cross tier interference where the direction of arrows indicate the interference in the network.

IV. PROPAGATION PATHLOSS MODELS:

In this work, urban scenario is considered for femto cell deployment and to calculate the path losses. Figure 4 shows MacroBase Station providing coverage to all user equipments and Femto Base Staion deployed in houses providing coverage to the irrespective user equipments. Propagation pathloss(PL) models are the reference formulas used to describe the propagation loss encountered in the downlink between Transmitter (femto base station) and Receiver which may be Macro User equipment(MUE) or Femto User Equipment (FUE) in this case. [10]

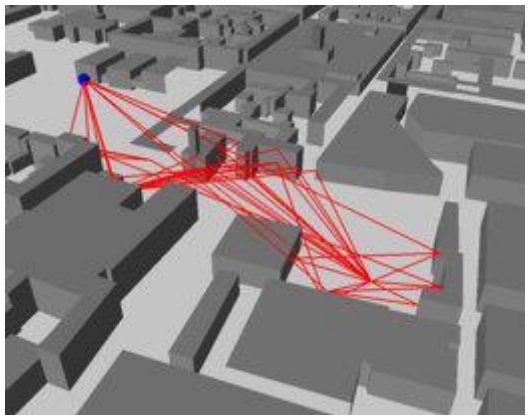

Fig 3.Urban Scenario [11]

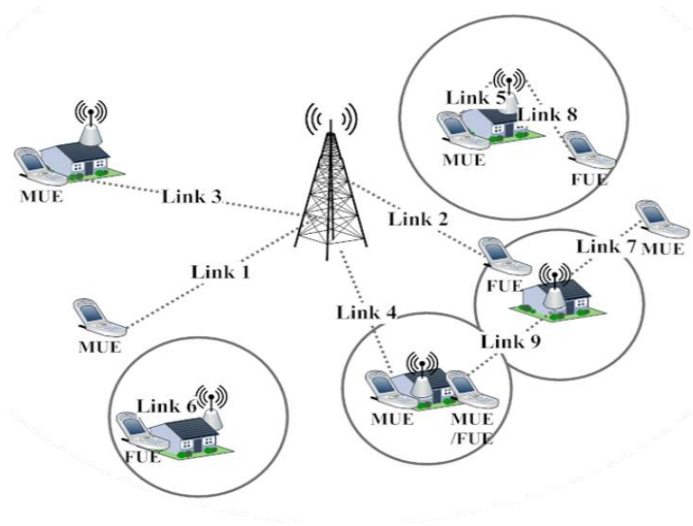

Figure 4 : Different Connection Links of Hybrid Macro-Femto Network[10]

Pathloss formulas are valid for Tx-Rx separation larger than 1 m. Pathloss (PL) model formulas can be summarized as follows :

1. UE is outside:

The following Pathloss(PL) model expressed in equation (1) is used when the transmitter is a macro BS and the receiver is either outdoor MUE or a FUE located outside the house such as link 1 and 2 respectively in figure 4.

$$PL(db) = 15.3 + 37.6\log R \qquad (1)$$

2. UE is inside a house:

The following PL model expressed in equation (2) is used when the transmitter is a macro BS and the receiver is either indoor MUE or a FUE located inside such as links 3 and 4 respectively in figure 4.

$$PL(db) = 15.3 + 37.6\log R + L_{ow} \qquad (2)$$

Where,

PL --- Path loss

R --- Distance between Transmitter and Receiver

Low --- Penetration loss of outdoor wall which is 10 dB. [10]

V. Simulation Result

In this section, the equation in section IV for pathloss models were used for simulation results in MATLAB and other parameters such as macro cell power, signal interference ratio were put into consideration. The throughput estimation was calculated for all the two cases specified in section III where in one case we assumed that both Femto user and Femto Access Point (FAP) have been placed outside the house, hence avoiding outdoor walls losses. In other case,when user equipment is placed inside the house, outdoor walls loss is present and hence throughput varies in all cases. This experiment evaluation will help us understand the behaviour of the whole Femto cell network with respect to user's position. [11]

Simulation result has been shown in figure 5 and 6 for respective cases.

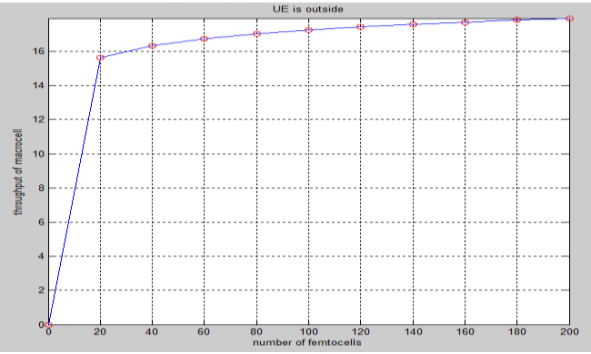

Fig 5.Pathloss when UE is outside

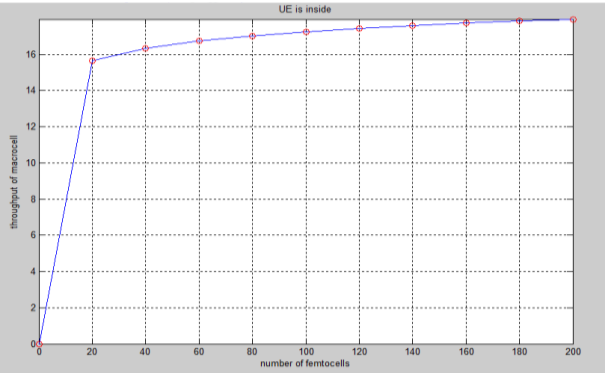

Fig 6. Path loss when UE is inside a house

VI. Conclusion

In this paper, we examined macro cell throughput considering pathloss models for each case. When user equipment (UE) is outside the house leading to no outdoor wall loss gives better throughput than another case. The case, when UE is inside the house shows less throughput because of outdppr wall loss. Femto cell has also been deployed in the house which causes interference to macro cell user.

The capacity performance is achieved due to the closeness of the base station to the end users (i.e. in case 1) and provides quality and data coverage. It is observed that for smooth and quality service from the service provider, the base station must be closer to the end users. So, more no. of cells should be set up to enhance coverage. This will cut off expenditures from the service provider, such as electricity bills, maintenance cost etc. so as to enable them to concentrate on quality of service for the end users of the network.

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