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Quality of Service Improvement in Femto Based Cellular Networks

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In this paper two existing channel allocation schemes such as opportunistic channel allocation scheme and orthogonal channel allocation scheme are discussed and their performance is compared to the proposed Max-SINR scheme.

To reduce the interference further a self-organized and intelligent resource allocation is also proposed .Parameter such as average SINR experienced by each femto user is calculated by varying the percentage of active Femto cells in a network. Simulation results are carryout using MATLAB.

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QUALITY OF SERVICE IMPROVEMENT IN FEMTO BASED CELLULAR NETWORKS

Strictly as per the compliance and regulations of:

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I. Introduction

Femtocells are low-power wireless access points that operate in licensed spectrum to connect standard mobile devices to a mobile operator's network using residential DSL (Digital Subscriber Lines) or cable broadband connections" -as stated by Femto Forum [1]. Femtocell [1], [2], [3] (also known as home BS or Femto Access Point (FAP)) is a short-range BS (Base Station) with ad-hoc nature of deployment. It intends to improve the performance of cellular services in SOHO (small office, home-office) indoor environments. It is motivated by the fact that due to the large penetration losses and attenuation in the indoor environments, the users often suffer from QoS degradation [3]. The purpose of Femtocells is to improve capacity (by allowing more frequency reuse) and coverage (by covering the dead zones formed due to insuficient macro signal penetration) in the indoor environment using cellular network standard.

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One of the major challenges in Femto deployment is interference. In general there are two types of interference that occur in two –tier Femtocell network architecture. Femtocells are overlaid on traditional cellular networks (i.e. the existing macrocell network) and share the same frequency spectrum with the macrocell. As the Femtocells and macrocell share the same frequency spectrum, sometimes there is a possibility that the channel is to be re-used either partially or totally which leads to cross-tier interference. At the same time there is also the possibility of channel to be reused by the two or more Femtocells in order to meet the guaranteed QOS to the user which leads co-tier interference. The throughput of the network is reduced due to the above interferences. Hence it is necessary to propose an effective interference management technique which would reduce the cross-tier and co-tier interference.

The main aim of this paper is to reduce the interference experienced by the Femto users. To reduce the interference we study the existing channel allocation schemes and compare these channel allocation schemes to the proposed channel allocation schemes.

II. Channel Allocation

Channel allocation is the process of allotting bandwidth, communication channels to the base stations. Once the channels are allotted then the users are allowed to communicate within the cells using the allotted channels. General there are three types of downlink channel allocations

1. Co-channel allocation
2. Partial Co-channel allocation
3. Orthogonal channel allocation

a) Co-channel allocation

In this channel allocation, the channels are shared among the macro users and also among the Femto users. Opportunistic channel allocation is one its example and is used in this paper. In opportunistic channel allocation scheme, the channels to the Femto and Macro Users are allotted based on the channel states experienced by each user for each channel. These pre-computation of channel states are done in RRM and are sent to all the femtos. The User whose channel state is more, that particular channel is allocated to the user. In this channel allocation type all the users are served with a channel.

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b) Orthogonal channel allocation

In this channel allocation, the channels are not shared among the Femto and Macro cells as well as among the Femto and Macro users. In this type of channel allocation, the channels to the Femto and Macro are allotted based on channel states experienced by each user for each channel. These pre-computation of channel states are done in RRM and are sent to all the Femtos. In this case if the number of channels is more than the number of users (Macro/Femto) all the users are served. But when number of users is more than the number of channels, all the users are not served. The user whose channel state is more when compared to the other users is served.

c) Partial co- channel allocation

In this channel allocation, the channels are shared by both the layers (i.e. both macro and femto cells), but among the users of each layer the allocation is orthogonal. Max-SINR channel allocation is an example is taken into consideration in this paper. In this type of allocation, the channels to the Femto and Macro Users are allotted based on the pre-computation of SINR experienced by each user for each channel. Based on the pre-computation of SINR values the user prioritises its channels and those channels are allotted to the femto users.

III. System Model

Simulation Parameters used a single tier cellular system which consists of 19 Femtocells in each macro cell. We have also determined the path loss models for Femtocells. In detail the simulation parameters considered are as follows:

Macro cell distance =500m
Number of users per each Femto=2
Total no. of Femto Users=38
The transmit power level at Macro BS (P) = 43dBm
The transmit power level at Femto BS (Pmacro) =20dBm
Thermal noise= -100 dBm
Total bandwidth =10 MHz.
Sub-carrier bandwidth= 180 KHz.
Sub-carriers for each sector=55.

a) Femto Deployment

In this paper we have considered a closed accessed uniform deployment of Femtocells all over the macro cells region, which serve 2 users randomly deployed in each Femtocell. On total 38 users areserved by the Femtocells. On the other hand 55 users are randomly deployed allover the macrocell region which is directlyserved by the MBS (Macro Base Station).

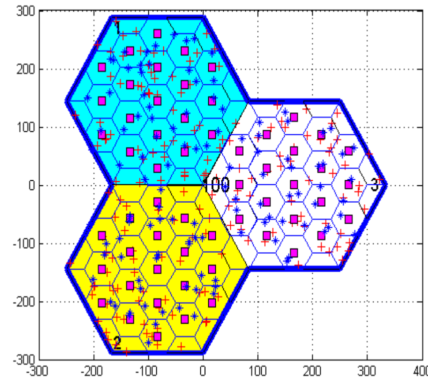

Figure 1 : System Model

Femtocells being plug-n-play CPE, its location as well as its activity period are random. Here in the above figure we have considered when all the Femtocells in the macrocell are considered active. When the FBS (Femto Base Station or Femto cell) is powered on by the user, it operates in UE (User Equipment) mode, where it scans the network, gets associates with relevant macro BS and follows the registration procedure. After the registration process the sub-channels for the Femto cell are allotted. Along with its registration the Femtos also get the information about its Neighbouring Femtocells.

b) Path Loss computation

Following path-loss models are used in simulations for estimation of distance dependent path-loss.

From Macro BS to Macro User Equipment

PL (dB) $=128.1+37.6*\log_{10}(d_1)$
From Macro BS to Femto User Equipment
PL (dB) $=128.1+37.6*\log_{10}(d_2)+$ WP
From Femto BS to Femto User Equipment
PL (dB) $=7+56*\log_{10}(d_4)+$ WP
From Femto BS to Macro User Equipment
PL (dB) $=37+20*\log_{10}(d_3)$

Where

D1 = Distance between Macro BS to Macro User Equipment.

D2 = Distance between Macro BS to Femto User Equipment.

D3=Distance between Femto BS to Macro User Equipment.

D4 = Distance between Femto BS to Femto User Equipment.

WP= wall penetration. (Assumed as 10)

c) SINR computation

$$des\ sig(FBSi_i, FUE_J) = P_{femto} * PL(d_{i,j})$$
$$noise\ interface(FBS_I, FUE_J) = \sum_{K=1}^{j} P_{femto} * PL(d_{ik,j} + P_{macro} * PL(d_{MSB,J}))$$

$$SINR_j^n = \frac{des\ sig}{noise\ inteference}$$

$$SINR_j^n = \frac{P_{femto} * PL(d_{i,j})}{\sum_{K=1}^{j} P_{femto} * PL(d_{ik,j} + P_{macro} * PL(d_{MSB,J}))}$$

n=nth sub-channel, j=jth femto user, i=ith femto cell

Using the above simulation parameters and computational formulas the average SINR experienced by each user is calculated for the three channel allocation schemes. out of three channel allocations the the scheme that gives the best performance to the femto users i.e the one which reduces the interfernce in Femto users is further modified to even more reduce the interference in the Femto users. This channel allocation scheme is further modified and simulated for even better performance to the Femto users.

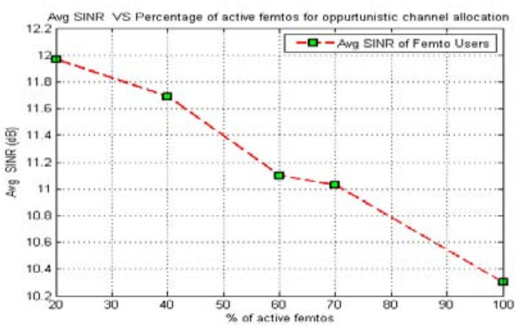

Figure 2 : Average SINR Vs Percentage of active femtos for opportunistic channel allocation

In the Fig 2 shows varying the percentage of active femtos the average SINR experienced by each femto user is obtained. It also shows that as the number of active femtos increases the interference among the femto user's increases and the average SINR decreases

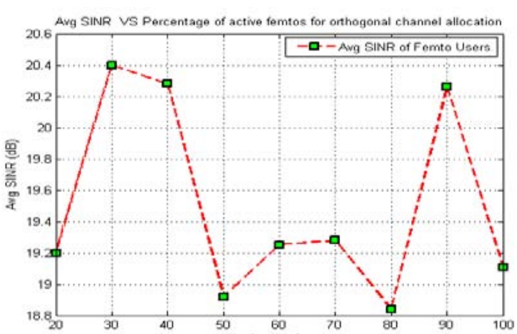

Figure 3 : Average SINR Vs Percentage of active femtos for orthogonal channel allocation

From the Fig .3 shows that varying the percentage of active femtos the average SINR experienced by each femto user is obtained. It also shows that as the number of active femtos increases the interference among the femto user's increases and the average SINR decreases.

d) Max-SINR channel allocation

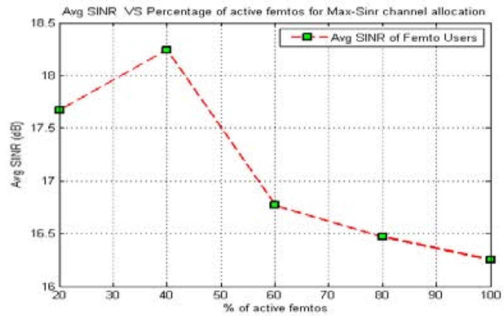

Figure 4 : Average SINR Vs Percentage of active femtos for Max-SINR channel allocation

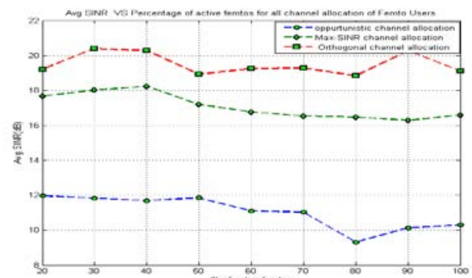

Figure 5 : Comparative analysis of Average SINR experienced by Femto Users varying the percentage of active femtos for the three channel allocation schemes

The above graph shows the comparitive analysis of all the three type of channel allocations which we have disscussed in this paper out of the three channel allocations the the scheme that gives the best performance to the femto users i.e the one which reduces the interfernce in Femto users is further modified to even more reduce the interference in the Femto users.

This channel allocation scheme is further modified and simulated for even better performance to the Femto users

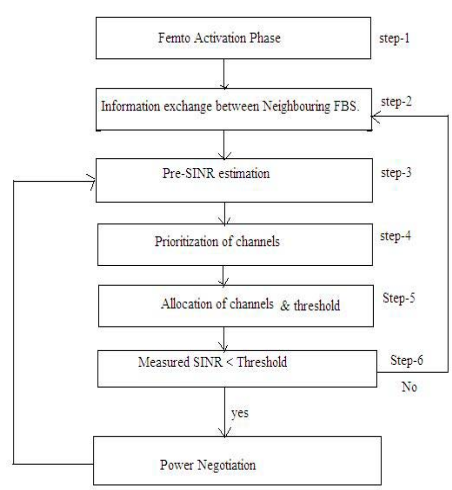

Figure 6 : The flowchart for proposed algorithm

Step 1: Femto Activation Phase

In this step the Femto is plugged in and series of signals are exchanged between Macro BS and Femtocell. In this way the Femto is activated.

Step 2 : Information Exchange with Neighbouring Femto BS

The proposed interface for signaling exchange between Femto BSs information will be obtained which are Neighbor discovery, Pilot signal power -to determine the path loss and signal power on each sub-channel -to evaluate interference on each sub-channel.

Step 3: Pre-SINR calculation

Each Femto BS can estimate the path loss to sender by using the pilot signal power indicated in the broadcast message and the measuring the pilot signal strength of the sender. Now, using the estimated path loss and the power applied to each sub-channel (from broadcast message), received signal strength from the sender in each sub-channel is estimated. This will help in evaluating the interfering power on each sub-channel as mentioned in step 2. With the estimated Signal, Interfering power, SINR is calculated.

Step 4: Prioritization of channels

In this step, based on the above estimated SINR values the channels are prioritized. The SINR values are ranked in descending order.

Step 5: Allocation of channels & Thresbhold

In this step based on prioritization of channels the channel with more SINR value is allotted to the Femto User. Based on the Femto Users SINR a certain threshold value (A.1.2) is allotted.

Step 6: Performance Evaluation

In this step, the SINR of all the users are compared to the threshold. if the SINR is less than the threshold arises a situation of conflict. It may happen due to high Femtocell density in the region.

Step 7: Power negotiation

In this step, theuser whose SINR is below threshold its respective Femto BS will coordinate with the neighbouring Femto BSs to resolve this coflict by mutually agreeing on either to reduce the transmit power levels. After this reduction of power, again the Pre-SINR calculation is done with its new transmit power (step 3) and proceeds to the next step of sub-channel allocation. This step is followed till at least 80% of all the femto users SINR is above than the allotted threshold value.

In this way to the Max-SINR channel allocation scheme, power negotiation between the Femto BS takes place to reduce the interference between the Femto users. Based on the values obtained which are noted down on the above table the graph is plotted.

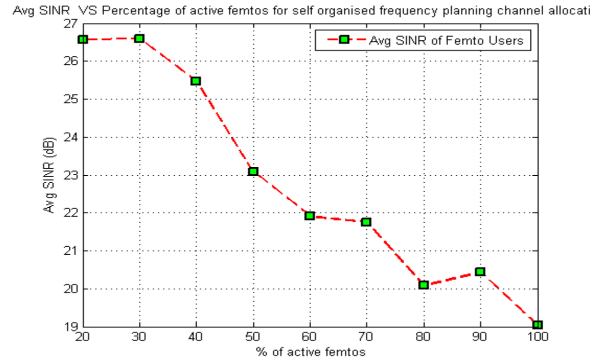

Figure 7 : Average SINR Vs Percentage of active femtos for self-organised frequency planning channel allocation

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