Asian Journal of Convergence in Technology *Volume III, Issue II*
ISSN No.:2350-1146, I.F-2.71

A Survey of Co-Tier and Cross-Tier Interference Mitigation in Femtocell Network

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***Abstract*— As number of wireless devices connected to system increases, there are challenges to operators and researchers to provide high data rates and wide coverage with high services in indoor environment. To fulfill the high speed data streaming and good quality of service demands of mobile users at home, femtocell networks are deployed in indoor premises. But interference occurs among same tier or between different tiers in two tier architecture. In this paper, interference mitigation techniques in femtocell network are discussed.**

Keywords*— *femrocell network, interference, co-tier, cross-tier

I INTRODUCTION

Wireless devices have become a secondary need of human being due to their fast day-to-day life. Hence, use of wireless device is increasing day by day. But still today users are facing issues such as poor signal strength and low call quality when used indoors leading to call drops. There is need of the mobile operators to find a competent solution to ensure customer trustworthiness and satisfaction resulting into improving signal strength in indoor premises. Although, picocells provide coverage, but these increases the network load and are also not cost effectively as are femtocells. The deployment of femtocells in indoor environment is one of the solutions to overcome these problems. Femtocells are low range devices having low transmission power which are deployed indoor.

As femtocells shares same frequency band with macro cell, interference occurs. Two tier networks consist of co-tier and cross- tier interference. When interference occurs in femtocell layer itself is known as co-tier interference. This means that when many femtocells are near to each other sharing same frequency band causes co-tier interference. Similarly, when interference occurs between different layers in two tier architecture is known as cross-tier interference. In this paper, different interference mitigation techniques are presented.

II CO-TIER INTERFERENCE

Femtocells are arranged in planned or unplanned manner. But practically, femtocells at home are arranged in unplanned manner by users. When femtocells are deployed in unplanned or ad-hoc manner, there are chances of getting devices closer that may interfere by creating background noise, thus reducing the sensitivity of femtocells. Interference in co-tier is higher than normal femtocell power level. As carrier to interference and noise ratio value is less, the probability of establishing communication via femtocell is impossible. This location is dead zone. The region where users get low quality of service is called as dead zone.

Basically, in two tier network, there are mainly two types of access mode: open access and closed access mode. The registered or unregistered mobile uses can access by femtocell in open access mode. In shopping centers and offices, the open access femtocells are mostly arranged where all mobile users can communicate with that femtocell. In closed access mode only registered mobile users can be entertainment by femtocells. Co-tier interference between neighboring femtocells is shown in Figure 1.

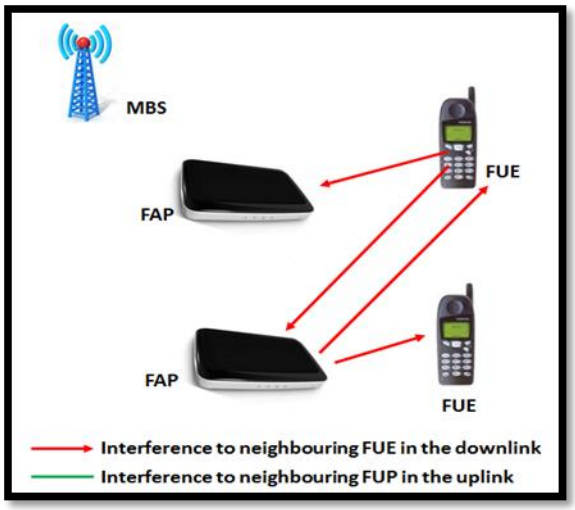

Fig. 1: Co-tier interference between neighboring femtocells

A. Intereference Mitigation Techniques

In order to avoid degraded performance of femtocells, there are different frequency allocation techniques.

- *Reuse-1*

Only one complete frequency band is used in a cell and same frequency band is used in other cells in this scheme. The spectrum efficiency is greatest and each cell uses entire band here as there is no partition. In this technique, inference is found on a large scale [1].

- *Reuse-3*

The whole frequency band is divided into three similar sub bands. The arrangement of these sub bands is done in such a way that interference is minimized. As compared to reuse-1 technique, interference is increased but capacity per cell is decreased [1].

- *Ericsson' Proposal*

In this technique, at the cell edge the part of frequency spectrum is used. At the center of the cell, the whole spectrum is used. The different spectrums have been used by adjacent cells. They cannot use neighbor's spectrum at the edge of cell.

- *Alcatel's Proposal*

In this technique, the existing spectrum is divided into 7 or 9 sub bands. The cell center having low transmitted power and uses all bands. Any of the three sub bands which are used by cell edges will not repeat in the adjacent cells. Three sectors have been created with the edge of cell that has 120 degree separated from origin. In this system, at the edge of cell the frequency reuse factor is 3/7.

- *Fractional Frequency Reused (FFR)*

In this technique cell is separated into two regions, the first is center region and second is edge region. The edge region is again into three parts. The frequency band is divided into two sub bands. At the center, one sub band is allocated. The remaining band is again divided into sub band. These divided sub band are allocated in such a way that at cell edges no interference can occur.

- *Soft Frequency Reused (SFR)*

This technique is comprised of reuse-1 and reuse-3. The regions are divided same as done in FFR that is edge region and center region. The frequency band is divided into two sub-bands. Then first band is given to the center region in every cell and other sub band is divided into three sub-bands. Now these sub-bands are allocated to edge region of each cell in a system.

- *Adaptive Soft frequency reused (ASFR)*

Physical Resource Blocks (PRBs) can be borrowed from cell edge whenever needed but vice versa is not possible. This give rise to call drop at edge of the cell. This is overcome and minimized in this technique. PRBs can be borrowed and utilized wherever required.

- *Cluster Aware Soft frequency reused (CASFR)*

In CASFR first Femtocell Base Station (FBS) scan signal level from Femtocell User Equipment (FUE). If interference occurs than serving FBS generates list of cell-ids of interfering neighbors, then it divides the cell into cell center and cell edge. For cell center and cell edge PRB allocation can be taking place and sends updates cell ids, PRB set information to the neighbor whose cell-id was deleted from the list. Allocating cell center radius which is nothing but a distance between interfering FUE to the serving FBS. If still interference is there then decrease cell center radius. Such method decreases interference and increases throughput to large scale.

III CROSS-TIER INTERFERENCE

There are dissimilar tiers in the network. This type of interference occurs between different network elements. This type of interference is more severe in Code Division Multiple Access (CDMA) co-channel deployment. This is due to both femtocell and macrocell which use the same frequency band. Typical cross tier interference between femtocell and microcell is shown in Figure 2.

B. Intereference Mitigation Techniques

The above mentioned fractional frequency reuse technique is also used in cross-tier interference mitigation. The following are the cross-tier interference mitigation techniques.

- *Power Control Approach*

There is a concept of power control on a cluster by cluster basis. In this concept initial power level is determined. It depends on the quantity of active femtocells in a cluster [2, 3]. There is another method which can be installed in distributed sensing. The game theory is used for distributed power control mechanism.

In order to increasing the capacity particle swarm optimization is introduced. In order to reduce the consumed power and enhance quality of service Hungarian algorithm is introduced.

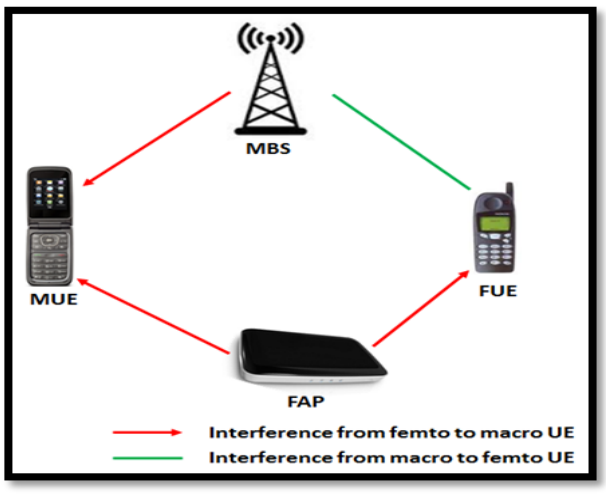

Fig 2: Typical cross tier interference between femtocell and macrocell

- *Resource Allocation Technique- Based Cuckoo Search Algorithm (RACSA)*

This is innovative method used in OFDMA based Long Term Evaluation (LTE) system [4]. Initially, in this technique best serving base station is found. Latter on suitable power and bandwidth are allocated for all users, thus minimizing cross-tier interference.

- *Genetic Algorithm (GA)*

The resource optimization has been handled by allotting proper band width and power assignment for each user [5]. The main limitation of GA is random convergence of solutions in Quality of Service (QoS) problems which related with fitness function.

- *Femto-aware Spectrum Arrangement*

The existing radio resources are grouped into two sections. The first section is completely dedicated to macrocell and second section is sheared between femtocells and macrocell[6]. The main limitation of this technique is that it is not suitable and viable for co-tier interference.

- *Q-learning*

Q-learning is a corroboration learning framework which uses concept of available environment by using an action value function. It provides excepted service of taking given action in a given condition afterward obeying same policy [7]. Based on intelligent and self-organizing network concept, estimation of performance and intelligence level of femtocell is introduced in the decentralized Q-learning algorithm.

- *Access Control Mechanism*

Access control mechanism allows only some user to gain access to personal femtocells. As mentioned above, in two tier architecture Open and Closed Access are used for Access control mechanism. Closed Subscriber Group (CSG), Open Subscriber Group (OSG) and Hybrid Subscriber Group (HSG) are three types which are in third generation partnership project (3GPP) [8]. The congestion is less in CSG, but provides good quality as it allows only certain users to get access. In OSG, everyone who comes in network allows to establish the connection. As a result, handovers and congestion problems are created. In HSG, users which are not subscribed are allowed to limited access but subscribed one has full access.

- *Interference Cancellation Technique*

This technique is meant to minimize signal at the receiver. When interference is created, the signals are stored in buffer and then interference signal are regenerated and subtracted from the signal. In demodulation process, only without result got after subtracting signal are demodulated and decoded. Interference are mainly classified as Successive Interference Cancellation (SIC) and Parallel Interference Cancellation (PIC). In SIC, signals are detected one after another. It first detects the strongest signal and then less stronger and so on. In PIC all signals are detected simultaneously. Another than this Multistage SIC (MSIC) is the interference cancellation technique in which several users are detected in parallel and then aggregate is subtracted from the received composite signal [9, 10].

- *Directional Antenna*

In this technique, uplink interference for the network is avoided and capacity is increased. Between the omni-directional antenna and Switched Beam directional antenna, Switched Beam directional antenna is comparatively more efficient as interference is reduced. Again E-plane horns based reconfigurable antenna reduces interference and increases link reliability. It also increases capacity odd OFDMA based femtocell systems [11, 12].

- *Receiver Decode algorithm*

Decoding algorithm includes dirty paper coding and Sphere decoding techniques. Dirty paper coding is technique in which data is precoded in order to minimize the interference [13].

- *Beam Subset Selection Strategy*

It services the cell in the particular direction and avoids in the other direction. Therefore, interference, jamming, noise are avoided and throughput is increased since it serves only in one direction. Mainly, cross- tier interference is minimized by this technique in femto network [14].

IV CONCLUSION

The reduction of distance between transmitter and receiver leads to improve capacity of wireless link. This can achieved by deployment of femtocell as a base station in home, office and shopping malls indoor premises. The different tiers in the network while transmitting to each other interference problem. The survey has been carried out to study different mitigation techniques used in femtocell network. One of the main classifications in two tier network is co-tier interference. Many techniques are being implemented in order to mitigate interference like reuse-1, reuse-3, FFR, SFR, ASFR, CASFR, Ericsson' Proposal and Alcatel's Proposal. Similarly, other interference mitigation technique is cross-tier interference Many techniques are being implemented in order to mitigate interference like Power Control Approach, RACSA, GA, Femto-aware Spectrum Arrangement, Q-learning, Access Control Mechanism, Directional Antenna, Receiver Decode algorithm and Beam Subset Selection Strategy. Considering various parameters to mitigate both co-tier and cross-tier interference FFR is the best suited technique. The interference avoidance strategies can make shared spectrum two tier networks a viable proposition in practical wireless network.

ACKNOWLEDGMENT

The authors express sincere thanks to their Principal Prof. Dr. Pramod Patil and Head of the Department of Electronics & Telecommunication Prof. Dr. S. R. Jog for the effort and support of them. The authors are also thankful to M. E. coordinator Prof. S. D. Chavan for his encouragement.

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