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SYSTEM CAPACITY IMPROVEMENT IN FEMTOCELL BASED LTE-ADVANCED

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Abstract: ***In order to successfully compete to other existing and future wireless, cellular and wire-line services, the network designers need to fully consider the technical constraints that influence the whole design process of this kind of networks. The Long Term Evolution (LTE) standard was designed to provide these mobile users with a better throughput, coverage and a lower latency. The aim of femtocells is to provide better indoor coverage so as to allow users to benefit from higher data rates while reducing the load on the macro cell. However, co-channel interference is a serious issue with femtocells that may dramatically reduce the performance of femto and macrocells. The system capacity and throughput decreases. As femtocells use the same spectrum as the macrocells, and the femtocells are deployed without proper planning, interference from femtocells to macrocells becomes a major issue. The interference from femtocells to macrocells can be reduced by different frequency reuse techniques. In different schemes for interference avoidance, femtocells use those frequency sub bands which are currently not being used within the macrocell, the process of assigning the frequency bands is based on those techniques.***

Keywords: LTE, Femtocells, Interference, Frequency Reuse Techniques**.**

INTRODUCTION

LTE – Long Term Evolution is a technology standard for high-speed wireless communications through cellular networks. Large telecommunication companies around the world have integrated LTE into their networks by installing and upgrading equipment on cell towers and in data centers. Technology called LTE-Advanced improves on standard LTE by adding new wireless transmission capabilities. LTE-Advanced supports a theoretical maximum data rate more than three times that of standard LTE, up to 1 Gbps, allowing customers to enjoy downloads at 100 Mbps or better. LTE is developed by the 3rd generation Partnership Project (3GPP) in order to make sure the effectiveness of its standards in the long term. Recently it is also known as 4th generation technology. LTE is the evolution of 3rd generation mobile technology, also called as Universal Mobile Telecommunications System (UMTS).

For indoor coverage enlargement the LTE has grown a femtocell. Femtocells have been attracting much attention recently for indoor coverage. The femtocell accompanies

differing advantages to both consumers and operators, such as improved system capacity, increased indoor coverage, made smaller capital, operation expense and Quality of Service (QoS). Femtocells are small, low power, low cost, short ranged and plug and play cellular base stations that can be placed in homes and can be directly connected to the backhaul network through Internet Protocol (IP). The advantages of having a femtocell are that the indoor coverage can be enhanced, coverage holes can be eliminated and also the operators can provide a better service at the cell edge.

LITERATURE REVIEW

Interference between Femtocell and Macrocell has been noticed by many alliances and has been solved to some extent but still there are issues such as co-channel interference between Femtocell and Macrocell still needs to be addressed. To mitigate the interference, several Frquency reuse schemes have been proposed. Some of these approaches are: fractional frequency reuse (FFR) method, soft frequency reuse (SFR) method, Partial frequency reuse(PFR), Reuse-1 and 3. Fractional frequency reuse (FFR) and soft frequency reuse (SFR) methods have been proposed to achieve frequency reuse factor I and reduce ICI in LTE networks.

Fractional Frequency Reuse (FFR) is a simple but useful technique to improve bandwidth usage across the network. In 2012, Christos Bouras, Georgios Kavourgias, Vasileios Kokkinos, Andreas Papazois published"Interference management in LTE femtocell systems using an adaptive frequency reuse scheme." In which the FFR techniques are applied to each of the macrocell, for which we can easily decrease the interference among the adjacent cells and increase the throughput. The soft frequency reuse (SFR) nowadays is considered as one of the most effective frequency planning strategies to mitigate inter-cell interference in cellular systems. In 2010, Yu, Yiwei, et al. published "Performance analysis of soft frequency reuse for inter-cell interference coordination in LTE networks."in which they first introduced in GSM, and then has been adopted under the 3GPP LTE framework with the aim of providing higher performance for users near the cell boundary. PFR divides the coverage area into center and edge regions. In April 2012, Mahmoud M. Selim, Mostafa El-Khamy, Mohamed El-Sharkawy, published “Enhanced Frequency Reuse Schemes for Interference Management in LTE Femtocell Networks” where PFR scheme divides the entire system bandwidth into 6 sub-bands.

In July 2013, Anand Bhikhubhai Patel, Prof. Sukant K. Chhotaray published “ Capacity and SINR improvement through Inter-cell Interference Management in LTE Femtocell networks”in which Reuse 1 available Frequency band is used in one cell and same is reused in Remaining cells.

PROBLEM STATEMENT

Inter-cell interference problem is addressed using a number of novel dynamic Inter-Cell Interference Coordination (ICIC) schemes. The issue of ICIC using pre-planned resource partitioning in a static manner can be traced back to the time when the cellular technology was first invented. The primary objective of such ICIC algorithms is to boost cell-edge performance with a minimal impact on network throughput. Additionally, such schemes requiring frequency planning cannot be applied to the emerging femto cellular networks, as

femtocells will be placed at the end user locations in an ad hoc manner. This interference arises because of the duplication of signals/resources in the neighbouring cells, and has the effect of degrading the service quality of the users. If each base station in the system uses the entire bandwidth resources simultaneously, any mobile station which is close to the boundary of a cell would suffer from interference created by the same resource in the adjacent cell.
Basically, there are two types of interference which are illustrated in figures.

- Cross-tier interference
- Co-tier interference

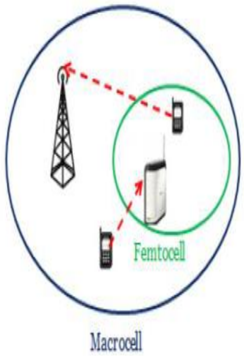

Fig 1. Cross tier interference   Fig 2. Co-tier interference [4]

- **Cross-tier**

□□Femto-Macro interference
□□Interference between femtocells and Macro cells, working on the same frequency may interfere with each other.

- **Co-tier:**

□□Femto-Femto Interference
□□Interference between neighbouring femtocells. UE transmitted signal reaching more than one femtocell.

The main objective is to study of the various cell structures- Femtocells and Macrocells. We can Compare different Frequency reuse techniques and then try to study an interference management scheme to overcome the interference between femtocell and macrocell. We can Evaluate SINR, throughputs and system capacity in the network using different reuse and improve the system capacity.

FREQUENCY REUSE TECHNIQUES

Frequency reuse is an integral concept of cellular communications which allows the users in different geographical positions to use the same frequency band. By reusing the frequency bands over and over again a cellular network provider can serve a large number of users simultaneously, therefore increasing the capacity of the system. Frequency reuse can considerably increase the spectrum efficiency of the cellular system, but proper planning is required to overcome the interference.

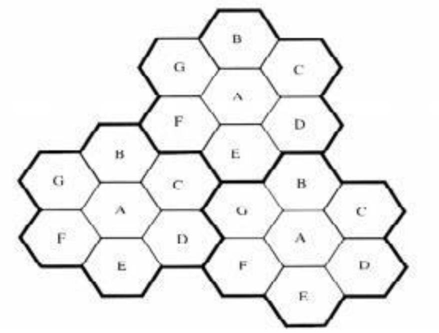

Fig 3. Frequency Reuse [4]

There are many frequency reuse allocation schemes used to reduce the interference through the system and improve the system capacity.

A. Reuse – 1

In this scheme available Frequency band is used in one cell and same is reused in Remaining cells as shown in figure.

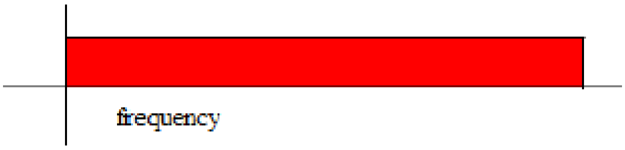

Fig 4. Band Allocation (Reuse-1) [2]

In figure red colour in every hexagon cell indicates that all the cells are using same frequency band. Femtocells will also be using same frequency band. Power allocation is shown in figure 4. Power is equally distributed in whole frequency band as shown in figure 5.

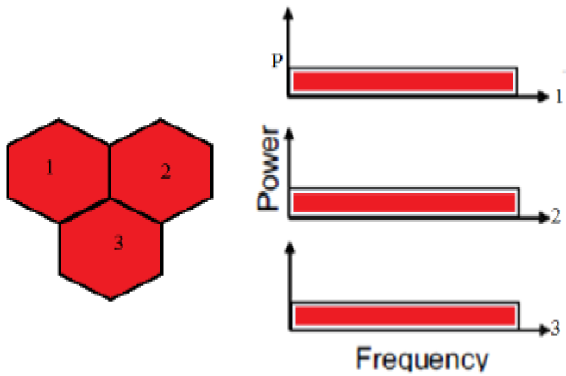

Fig 5. Frequency and power allocation (Reuse-1) [2]

B. Reuse – 3

The entire frequency band is divided equally into 3 sub-bands as shown in Figure 6. Each sector is assigned one frequency sub-band. The transmission power level of each sector is set to be 3P where P is the reference power level of Reuse-1 scheme. We propose that femtocells at each sector can use the two remaining frequency sub-bands not used by macrocells. The Reuse-3 scheme provides complete separation in frequency between the macrocell and femtocell networks at the expense of spectral efficiency.

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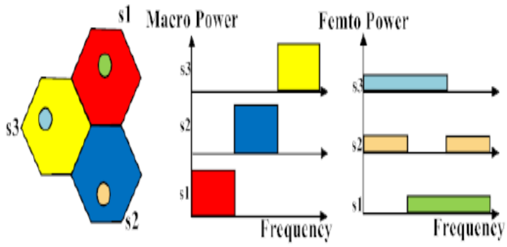

Fig 6. Reuse- 3 scheme [1]

C. **Fractional Frequency Reuse**

Fractional Frequency Reuse (FFR) is a simple but useful technique to improve bandwidth usage across the network. FFR techniques are applied to each of the macrocell, for which we can easily decrease the interference among the adjacent cells and increase the throughput. FFR is applied to each macrocell of the topology, as shown in Figure 7. in order to reduce interference between adjacent cells and enhance throughput.

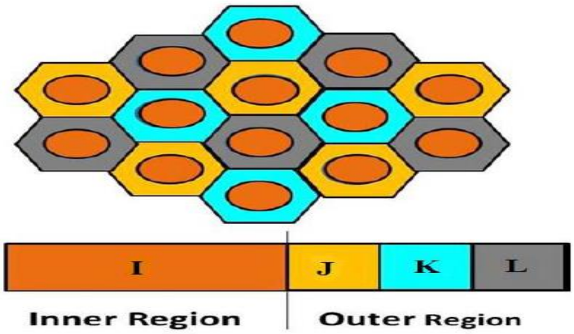

Fig 7. Frequency Band [3]

Each hexagonal cell of the network is divided into two region one is inner (orange color) and the other is the outer region (colors yellow, blue and gray). The full frequency band is divided into two equal parts. The first part of this total frequency band is given to central zone with a reuse factor of one and the frequency band is denoted as I, while the rest frequency band is equally divided into three sub-bands, with a reuse factor of three and the frequency bands are denoted as J, K and L respectively.

In the outer region of a macrocell, if a femtocell is located, then we can reuse the sub band for the femto users which are used in the inner region. On the other hand, if in the inner region of the macrocell a femtocell is exist, and then the femtocell cannot reuse that sub-band which was already assigned to the users which are in cell edge of that macrocell.

D. **Soft Frequency Reuse**

The soft frequency reuse (SFR) nowadays is considered as one of the most effective frequency planning strategies to mitigate inter-cell interference in cellular systems.

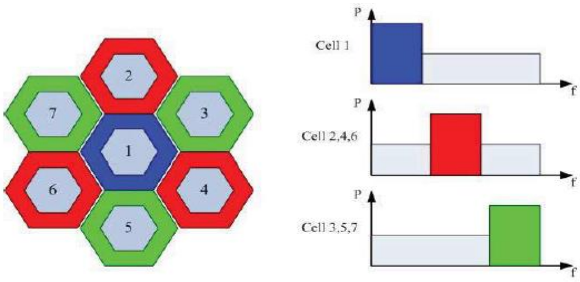

Fig 8. The frequency planning and power allocation for the SFR scheme [3]

In SFR, the available spectrum is divided into two reserved parts: a cell-edge band and a cell-center band. Users within each cell are also divided into two groups, cell-center users and cell-edge users, based on their distance to the base station or other differentiating factors. Cell-edge users are restricted to the reserved cell-edge band while cell-center users have exclusive access to the cell-center band and can also have access to the cell-edge band but with lower priority. The cell-edge users must transmit on a higher power level in order to improve their data rates, whereas the cell-center users can transmit with a reduced power level.

E. Partial Frequency Reuse

PFR scheme divides the entire system bandwidth into 6 sub-bands as shown in Figure 9. The first 3 sub-bands are reserved for center MUEs at any sector. These sub-bands are called Common Sub-bands. Each of the three remaining sub-bands is reserved for edge MUEs at different sectors. The transmission power level for sub-bands of the edge region is set to be 2/3 of the total transmission power**.** The transmission power level for sub-bands of center region is set to be 1/3 of total transmission power.

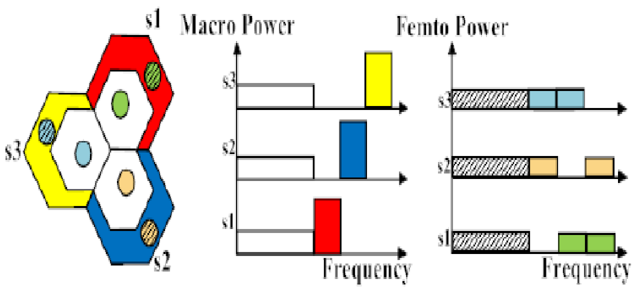

Fig 9. Partial Frequency Reuse [2]

Our proposed femtocell allocation scheme also depends on categorizing femtocells into center and edge femtocells. Cen-ter femtocells at each sector can only operate on the two sub-bands not allocated to the center and edge MUEs of this sec-tor. Edge femtocells at each sector can operate on the same two sub-bands besides the common sub-bands because of limited interference power level received from center BS.

CONCLUSION

Femtocell technology can provide many advantages to the mobile subscribers and the service providers. Thus, femtocells could be viewed as a promising option for next generation wireless communication networks such as OFDMA-based LTE networks. The interference mitigation techniques are based on the idea of frequency reuse in order to reduce SINR and achieve higher values of throughput. The proposed mechanism selects the optimum values for the application of the FFR based on the maximization of user satisfaction. Reuse-1 is the best scheme in terms of spectral efficiency, but has degraded QoS, and fairness. Although Reuse-3 is the best scheme in terms of QoS, and fairness, its poor spectral efficiency doesn't make it a good choice. SFR can effectively mitigate inter-cell interference at the medium traffic load by achieving significant throughput improvement.

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