

FREQUENCY REUSE TECHNIQUES FOR REDUCTION OF INTERFERENCE IN FEMTOCELL LTE ADVANCED

Paramita P Chaudhari¹, Hiren Tailor²

PG student, EC Dept, SNPIT & RC, Umrakh, Bardoli, Gujarat, India¹

Assistant Professor, EC Dept, SNPIT & RC, Umrakh, Bardoli, Gujarat, India²

Abstract: The Cellular Wireless Technology has been developing the fastest compared to any other technology. Long Term Evolution (LTE) is a standard technology for high-speed wireless communications through the cellular Networks. It is used for the mobile users for better throughput and coverage. LTE Advanced is the improve version of standard LTE. Deployment of Femtocell In LTE-A network provide better indoor coverage for users. Interference occurance is a serious issue when Femtocells are used in network. The interference Problem is generated between Femtocell and Macrocell when they use the same frequency. This interference can be reduced by different frequency reuse techniques. This work is based on Soft Frequency Reuse (SFR) frequency reuse Technique. The Proposed Method of Varied Power Distribution is used to improve network efficiency and Reduce the Interference. For reduction of interference there are different frequency reuse techniques are there. In these schems Femtocells uses those frequency sub bands which are currently not being used by the Macrocell, the process of assigning the frequency bands is based on those techniques.

Keywords: LTE, Interference, Femtocell, frequency Reuse Techniques.

INTRODUCTION

Long Term Evolution (LTE) is a standard technology for high-speed wireless communications through cellular networks. 3GPP Release 8 known as Long Term Evolution is the evolution of the third generation mobile communications standard. LTE standard aims to increase system data rates especially for cell edge zones and improve spectrum efficiency to avoid the problem of Interference. Long Term Evolution (LTE) is designed to Increase the speeds of 3G networks for mobile devices. LTE-Advanced is the upgrade version of standard LTE. LTE-Advanced supports maximum data rates Upto 1 Gbps more than three times of standard LTE at downloading speed at 100 Mbps. LTE is developed by the 3rd generation Partnership Project (3GPP). Recently it is also known as 4th generation technology. The most of cellular traffic occurs in indoor area. It is Resolved by deployed the Femtocell in Network. Femtocells are home base stations which are used to in the network to connect mobile devices to a mobile operator's network. Femtocells are useful for both consumers and operators, such as improved system capacity, increased indoor coverage, and QoS. Femtocells are small, low power, low cost, short ranged and plug

and play cellular base stations that can be placed in homes/offices because they can directly connected to the network. femtocell are very useful for enhance for indoor coverage, for better Throughput and also provide better service at the cell edge.

LITERATURE REVIEW

Interference between Femtocell and Macrocell are usually generated in the network and has been solved by the reuse techniques. To mitigate the interference there are Frequency reuse techniques. Which are: Reuse-1, Reuse-3, fractional frequency reuse (FFR) method, soft frequency reuse (SFR) method, Partial frequency reuse (PFR).

Fractional Frequency Reuse (FFR) technique is used to improve Bandwidth usage to the network. In 2014, jing Lim, R Badlishah and M Jushoh published “LTE-fractional frequency Reuse (FFR) optimization with femtocell Network”.In which the FFR techniques are applied with Femtocell and without Femtocell, for which we can easily decrease the interference among the adjacent cells and increase the throughput. In their Paper they improved the network by 98%.

The soft frequency reuse (SFR) is one of the most effective frequency Reuse Technique to Reduced the inter-cell interference in cellular Network. In 2016, Iskandar and H. Nuraini published "Inter-Cell Interference Coordination with Soft Frequency Reuse Method for LTE Network."in which they They simulate the Network by Coverage Dimensioning of network planning and capacity Dimensioning. After Comparing the results the network evaluation. As per results it's prove that the Spectrum Efficiency is increased and it improve the network performance at the cell edge area.

PFR is the Partial frequency reuse Technique. In this technique it divides the coverage area into center and edge regions and they give equal power to cell edge and cell center area. So both the cell edge and cell center users can access the frequency at higher data rates. In April 2016, Dhara shah, published “Mathematical Analysis for Maximization of Cell Capacity using Partial Frequency Reuse in LTE Network” where PFR scheme divides the entire system bandwidth into 6 sub-bands. She used the Fixed and Variable User Position in the network. After analysis the results shows that the capacity is decrease when the distance of user and base station are higher.

In July 2013, Anand B. Patel and Prof. Sukant Chhotaray” Frequency Reuse Schemes for “Interference Management in LTE Femtocell Networks: Issues and Approaches”in which Reuse 1 and Reuse 3 are used. In Reuse 1 the available Frequency band is used in one cell and same is reused in other cells. So the Interference is Maximum in this technique and in reuse 3 the available frequency band is divided into 3 sub band so the interference is less as compare to reuse 1 but network capacity is decreased in this technique.

PROBLEM STATEMENT

The deployment of Femtocells results in a change in the topology of the ordinary macro-cellular network. Inter-cell interference avoidance without impacting cell throughput is a challenging task. The new network architecture is composed of two different layers; the Macrocell layer and the Femtocell layer.This new network is usually called the two-tier network. The presence of Femtocells and Femtocell in the same geographic area and they

transmitted on the same frequency band will result in the most common problem in any system which is interference. The primary objective of such Inter-cell Interference is to Improve cell-edge performance with a minimum effect on network. So such schemes need frequency planning so deploying femtocell in networks, as femtocells will be placed at the user locations. This interference arises because of the duplication of signals 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. So any mobile station which is close to the cell would suffer from interference.

There are two types of interference: Cross-tier interference and Co-tier interference.

- **Cross-tier:** Interference between femtocells and Macro cells, working on the same frequency may interfere with each other (Femto-Macro interference).
- **Co-tier:** Interference between neighbouring femtocells. UE transmitted signal reaching more than one femtocell (Femto - Femto Interference)

The main goal is to study of the various cells Femtocells and Macrocells. We 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, BER and system capacity in the network using different reuse and improve the system capacity.

FREQUENCY REUSE TECHNIQUES

Frequency reuse is a useful concept of cellular communications which allows the users in different geographical Location to use the same frequency band. By reusing the frequency bands over and over again a cellular network provider can use a large number of users simultaneously, therefore increasing the capacity of the system.

Frequency reuse can be used to increase the spectrum efficiency of the cellular system, but proper planning is required to overcome the interference caused by the common use of the same frequency bands.



Fig 1. Frequency Reuse

There are Different types of frequency reuse allocation schemes are there which is used to reduce the interference.

1] Reuse – 1

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

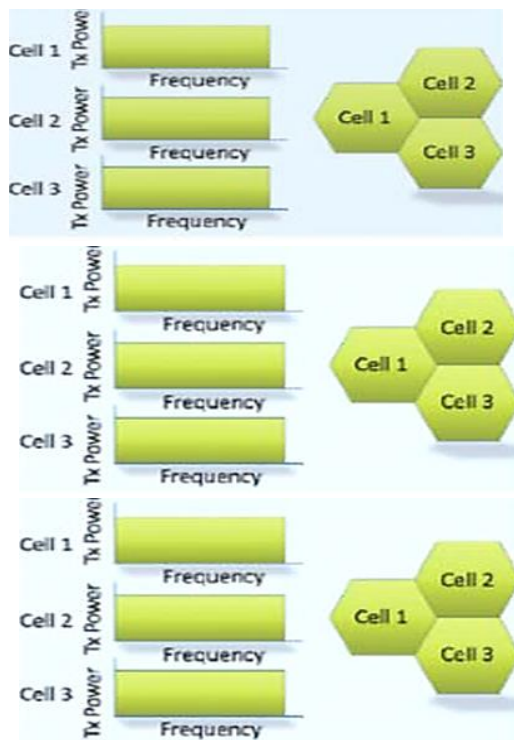


Fig 2.Reuse-1 Scheme [2]

In figure we can see that every cell shows that all the cells are using same frequency band. Femtocells will also be using same frequency band. Power is equally distributed in whole frequency band. So the Interference is maximum in this technique.

2] Reuse – 3

The frequency band is divided into 3 sub-bands as shown in Figure. Then these sub bands are allocated to cells in a manner that there is no interference at edges of cells. The transmission power level of each sector is set to the reference power level of Reuse-1 scheme. The femtocell at each sector use the 2 remaining frequency sub-bands not used by macrocells. So the Interference is less as compare to the Reuse 1 but the system capacity is reduced in this technique.



Fig 3.Reuse-3 Scheme

3] Fractional Frequency Reuse

Fractional Frequency Reuse (FFR) is very useful technique to improve bandwidth to 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.

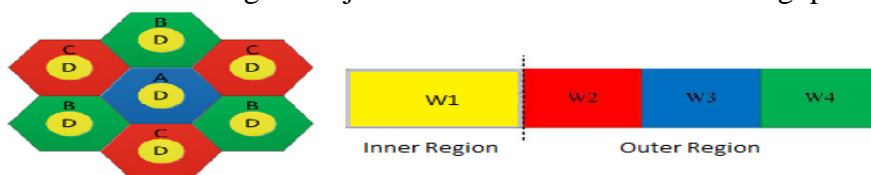


Fig 3. Fractional Frequency Reuse Scheme

As shown in Figure 3. FFR is used to reduce interference between adjacent cells and enhance throughput. Each cell of the network is divided into two region one is For center (Blue color) and the other is for Edge region (Red, yellow and Green colour). The full frequency band is divided into two parts. The first band is given to central zone with a reuse factor of one which is $W1$ and while the other frequency band is equally divided into three sub-bands, with a reuse factor of three and the frequency bands are denoted as $W2, W3$ and $W4$ 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 edge region and if the femtocell is in the inner region then they cannot reuse that sub-band which was already assigned to the edge users of that macrocell.

4) 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.

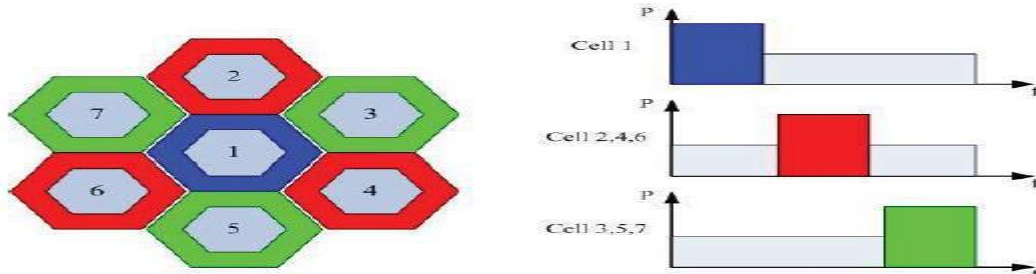


Fig 4. The frequency planning and power allocation for the SFR scheme [3]

In SFR, the available frequency band is divided into two bands: a cell-edge band and a cell-center band. The basic idea of SFR is to apply a frequency reuse of one at the cell center area and a higher frequency reuse factor at the cell edge area. Users in each cell are also divided into two groups, cell-center users and cell-edge users. Cell-edge users are restricted to the reserved cell-edge band while cell-center users can access to the cell-center band and also they can 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.

5) Partial Frequency Reuse

PFR scheme divides the entire system bandwidth into 6 sub-bands as shown in Figure. The first 3 sub-bands are reserved for center Users. These sub-bands are called Common Sub-bands. Each of the three remaining sub-bands is reserved for edge users.

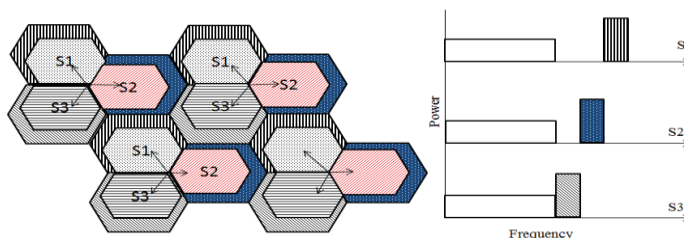


Fig 5. Partial Frequency Reuse

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.

The proposed method uses varied power distribution. The proposed idea is to mitigate Inter-cell interference which is caused due to complete co channel operation and low power signal received from Macrocell BS. By giving a power factor to the center users first and then the remaining power along with the already equally distributed PRB power to the edge zone users. Depending on the number of center users power factor is given to see whether cell edge capacity is improving or not. Power allocated is different to center users and edge users. Depending on the frequency reuse scheme used, power allocated to each PRB differs.

SIMULATION RESULTS

The average PRB efficiency with respect to the number of femtocells are shown in figure 6 below. The simulation result shows a significant improvement by proposed method in the average PRB efficiency. Our proposed scheme has lower average PRB efficiency when the number of femtocells is 1; however, the average PRB efficiency still improves by the proposed method. The PRB efficiency is higher when the number of femtocell are higher. The signal to interference ratio is lower when the no of femtocell is less.

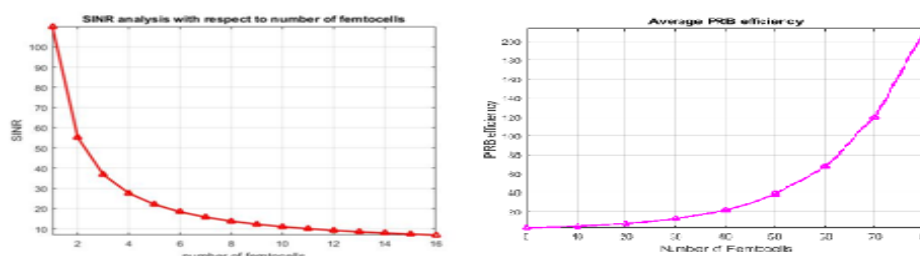


Fig 6. Simulation Result of SINR and Average PRB of Proposed method

CONCLUSION

Femtocell technology can provide many advantages to the mobile subscribers and the service providers. Femtocells could be viewed as a promising option for next generation wireless communication networks such as OFDMA-based LTE networks. The interference Reduction techniques are based on the idea of frequency reuse in order to reduce SINR and achieve higher values of throughput. Varied power distribution which is a proposed method is employed to give sufficient power to center users to receive signal and remaining power to edge users so that edge zone Macro users have more power to receive signal without any interference from Femtocells and its users. 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 for efficiency, but has lower QoS. Reuse-3 is the best scheme in terms of QoS but 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.

ACKNOWLEDGMENT

I would like to express my deep sense of gratitude to my guide and Head of the Department **Mr. Vipul H Mistry** for guiding me throughout to create this paper and also for his full dedication and devotion of time and inspiring me to put my best effort. I would further like to thanks my Guide **Mr. Hiren Tailor** and all the faculty members who helped me by giving valuable suggestions and encouragement and gave me this opportunity and Mr. J.N.Patel,

Chairmain Vidyabharti Trust, Mr. K.N.Patel, Hon. Secretary, Vidyabharti Trust, Dr. H.R.Patel, Director, S.N.P.I.T.&R.C.,Umrahk, Bardoli, Gujarat,India for their motivational & infrastructural supports to carry out this research. And I also want to thank God.

REFERENCES

- [01]J. Lim, R. Badlishah, and M. Jusoh, "LTE-fractional frequency reuse (FFR) optimization with femtocell network," 2nd International Conference on Electronic Design (ICED), pp. 527–532, 2014. IEEE.
- [02]Iskandar and H. Nuraini"Inter-Cell Interference Coordination with Soft Frequency Reuse Method for LTE Network" 2016 2nd International Conference on Wireless and Telematics (ICWT).. 12 Aug 2016, IEEE. <https://doi.org/10.1109/ICWT.2016.7870852>
- [03]Dhara C. Shah, Akshay Malhotra "Mathematical Analysis for Maximization of Cell Capacity using Partial Frequency Reuse in LTE Network" IEEE International Conference On Recent Trends In Electronics Information Communication Technology, May 20-21, 2016.
- [04]Uttara Sawant and Robert"A Novel Metric to Study the Performance of Sectorized Fractional Frequency Reuse Techniques in LTE " Wireless Telecommunications Symposium (WTS)2017,Conference on 26-28 April 2017. IEEE <https://doi.org/10.1109/WTS.2017.7943553>
- [05]Eman S, Sami A. El-Dolil and Mohammed "Performance Enhancement based Resource Allocation Scheme using Soft Frequency Reuse for LTE Femtocell Networks"2017,34th NATIONAL RADIO SCIENCE CONFERENCE (NRSC 2017), March 13-16, 2017
- [06]P. Lee, T. Lee, J. Jeong, and J. Shin, "Interference management in LTE femtocell systems using fractional frequency reuse," in Advanced Communication Technology (ICACT), 2010 The 12th International Conference on, vol. 2, pp. 1047–1051, IEEE, 2010.
- [07]Yiwei Yu ,Markus Mueck and Gengfa Fang "Performance Analysis of Soft Frequency Reuse for Inter-cell Interference Coordination in LTE Networks".2010 10th International Symposium on Communications and Information Technologies. 29 Oct. 2010 IEEE. <http://ieeexplore.ieee.org/document/5665044/>
- [08]Uttara Sawant and Robert "Evaluation of Adaptive and Non Adaptive LTE Fractional Frequency Reuse Mechanisms" 2017 26th Wireless and Optical Communication Conference (WOCC).8April2017.IEEE<https://doi.org/10.1109/WOCC.2017.7928998>
- [09]Anand B. Patel and Prof. Sukant Chhotaray "Frequency Reuse Schemes for Interference Management in LTE Femtocell Networks: Issues and Approaches" IEEE.ICARET 97..http://searchdl.org/public/book_series/AETS/2/97
- [10]Giovanni Giambene and Van Le "Performance Evaluation of Different Fractional Frequency Reuse Schemes for LTE" 2014. Euro Med Telco Conference(EMTC).15 oct 2014.<https://doi.org/10.1109/EMTC.2014.6996644>
- [11]MEGHANA ADUSUMILLI "A Novel Resource Allocation Methodology To Improve Overall Network Efficiency In LTE Heterogeneous Femtocell Networks." International Research Journal of Engineering and Technology (IRJET). Volume: 03 Issue: 09 | Sep-2016. www.irjet.net <https://www.irjet.net/archives/V3/i9/IRJET-V3I9276.pdf>