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Inter-cell interference mitigation using Intelligent Frequency Allocation-Dynamic Power Allocation in LTE systems

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***Abstract*—** Traditionally, all new emerging wireless technologies require wider bands than the existing ones. However, the frequency spectrum is a limited resource and to be utilized more efficiently. Therefore, the scarcity of the spectrum is a major problem that plays most important role in the growth of wireless communications and cost billion dollars business. Interference is an unwanted component of several of signals transmitted from different transmitters in wireless communication systems. In LTE system which uses reuse factor of one, which require whole available spectrum is used in each cell of the network. The areas falls in interference power dominant in comparison to required signal power. In the paper, Intelligent Frequency Allocation-Dynamic Power Allocation (IFA-DPA) is proposed. The algorithm is implemented on Cost-231 propagation model, The results obtained are very much promising to the inter-cell interference problem LTE networks and proved its usefulness.

Keywords- LTE systems, inter-cell interference, SFR, Interference Alignment, IFA, DPA.

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I. INTRODUCTION

Nowadays, more and more people become mobile subscribers. The global economy recession did not stop people from using the mobile communication services. Until the year 2012, the number of worldwide mobile subscribers has reached 5.8 billion and it is estimated that there will be 10 billion mobile subscribers by 2014 globally [1]. Mobile phones have become an important part of everybody's daily live. Voice service through the mobile phone is not the only function anymore. In recent years, more and more mobile subscribers start checking their email, surfing the web, downloading music and even playing real-time games on their wireless devices [2]. So there is a rapid growth in demand of broadband wireless data service. The operator assessment in [3] has shown that data traffic has increased to a level more than 10 times over the voice traffic in the year 2013 and the analyst forecast report shows that, because of increasing competition and price reduction, the declines in mobile voice Average Revenue per User (ARPU) will continue in the year 2014. However, the progress in broadband data service will ensure that the total ARPU grows [4]. In order to meet the requirements of serving mobile subscribers, the mobile operators must develop their short and long term technology strategies based on new and innovative mobile data services. Right now in the wireless industry, there are several paths or solutions which can lead the mobile operator to the future mobile broadband. Each mobile operator will take one path over the other depending on their own business strategies and timetables. But one ultimate goal has been agreed that the new technology should be an efficient Internet Protocol (IP) wireless network capable of supporting voice, video, messaging and data services [5]. LTE is such a promising technology which can meet the needs of future IP-based services [6], and more and more mobile operators have converged on the LTE technology, as they believe that LTE will offer them and their customers the most benefits and the best interests. Numerous techniques are proposed by many authors for minimization of interference [8][9][10][11][12].

The remainder of the paper is organized as follows: Section II describes the interference in inter-cell interference in LTE systems. The section III describes about cost -231 model. In section IV proposed technique to mitigate the ICI in LTE systems has been discussed. Section V and VI outlines the implementation and simulation results. Finally, the conclusions and future directions are outlined in Section VII.

II. INTERCELL INTERFERENCE IN LTE SYSTEMS

In any cellular mobile communication system, two major classes of interference must be considered, namely: intra-cell interference, and inter-cell interference. In the former, interference is caused between frequency channels, within the same cell, due to adjacency of both frequencies and power leaked from one channel to an adjacent channel. In the latter, interference is caused by a frequency channel in one cell, on the same frequency channel used in an adjacent cell.

$$y^n = \frac{p_{desired}}{p_{intra-cell} + p_{inter-cell} + \frac{p_{noise}}{n}}$$

y^n : signal to noise and interference ratio
$p_{desired}$: power of the desired user's signal
$p_{intra-cell}$: power of intra-cell interference
$p_{inter-cell}$: power of inter-cell interference
p_{noise} :white noise power
n: frequency reuse factor (FRF)

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As the user equipment (UE) moves away from the serving eNB, the degradation in its SINR can be attributed to two factors. On the one hand, the received signal strength decreases. On the other hand, ICI increases as the UE moves close to a neighbouring eNB, as illustrated in Figure1

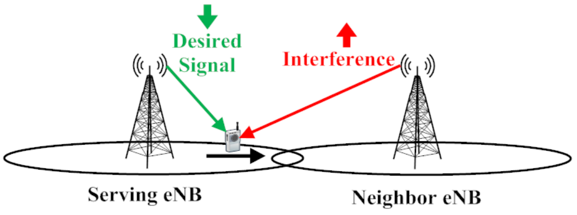

Figure 1: Illustration of UE moving away from its serving eNB

In LTE, orthogonality between users, within the same cell, is guaranteed in both uplink, and downlink. Therefore, it can be said that the LTE system, is an inter-cell interference limited system. The SINR equation reduces to be:

$$\gamma^n = \frac{P_{desired}}{P_{inter-cell} + \frac{P_{noise}}{n}}$$

III. COST231 HATA MODEL

A model that is widely used for predicting path loss in mobile wireless system is the COST-231 Hata model. The COST-231 Hata model is designed to be used in the frequency band from 500 MHz to 2000 MHz. It also contains corrections for urban, suburban and rural (flat) environments. Although its frequency range is outside that of the measurements, its simplicity and the availability of correction factors has seen. it widely used for path loss prediction at this frequency band. The basic equation for path loss in dB is

L=46.3+33.9log (f)-13.82*log(HBS)+(44.9-6.55*log (HBS))*log(d) - a+ cm

- $a=3.2*\log(11.75*hr)^2-4.97$
- Cm=3 db (urban-large cities)
- Cm=0db (urban-small cities)
- Cm=-2(log(f/28))-5.4db (suburban)
- Cm=-4.78*log(f)+18.33*log(f)-40.64

IV. PROPOSED SCHEME (INTELLIGENT FREQUENCY ALLOCATION-DYNAMIC POWER ALLOCATION)

Allocation of frequency plays a vital role in the performance of LTE system. there is more interference at cell edges in compare to cell center. So according to IFA scheme we have divided whole band into two parts one frequency is assigned to cell center and another at cell boundary. Effect of the IFA will be shown in simulations results .

- We have frequency band 150mhz -2000mhz.
- This band is first divided into two bands

F1=150-1300mhz

F2=1300-2000mhz

- F2 is used at cell center
- F1 is further divided into small bands and used at cell boundaries for different cells.

Transmitted power level also affects the performance of the system .we have applied the concept of dynamic power .In the simulation transmitting power range: 42db-48db is taken .In DPA power is boosted to 48 db from 42 db for cell-end user. Improvement in systems performance will be shown in simulation results. By increasing the power level for end user interference level can be minimized. .

V. EXPERIMENTAL SETUP

In this work LTE simulations are implemented with the help of MATLAB to investigate the performance of different protocol architectures. For these experiments, a network of 7 cells with random deployment is made The base station was located at the center of each cell. A basic consideration is made about base station height, receiver height, cell size , user mobility, frequency allocation etc These parameters are summarized in Table 1.

TABLE 1

Propagation model LTE-231

Factor	Specifications
Frequency range	150Mhz -2000Mhz
Transmitter power	42db-48db
Transmitting Antenna gain	18db
Transmitter height	30 m-200m
Receiver height	1m-10m
Distance between ransmitter and receiver	1 km-20 km

VI. SIMULATION RESULTS

To check the performance of intelligent frequency allocation – dynamic power allocation algorithm cell structure has been taken.

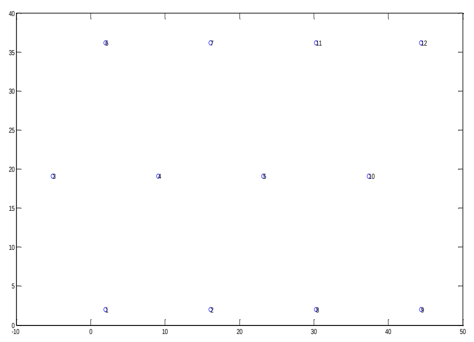

Figure 2: cell network

Figure 2 shows basic cell network of 12 cells we will select a target cell and will calculate the inter-cell interference in that particular target cell after that we will apply proposed algorithm to mitigate inter-cell interference

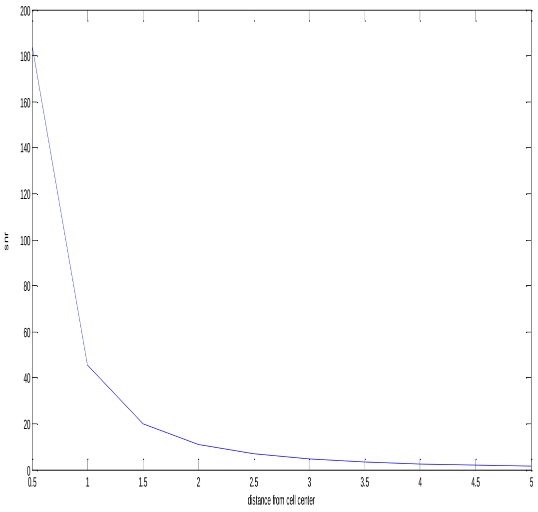

Figure 3: Signal to noise ratio when user moves away from the cell Centre

Figure 3 shows the variation between SNR and user mobility when user moves towards x- axis .it is clear from the graph that at cell centre user's strength is sufficient for efficient communication .but as user moves towards cell boundaries SNR values decreases rapidly so inter-cell interference is a serious problem at cell edges in comparison to cell centre.

TABLE 2
Input Parameters for simulation

Input Parameter	Specifications
Transmitter height(ht)	30 m
Receiver height(hr)	1m
User mobility	100m-1km
Cell size	up to 1km
No. Of users	50/cell
Propagation model	cost-231
F1	728mhz(at cell edge)
F2	1805mhz(at cell center)

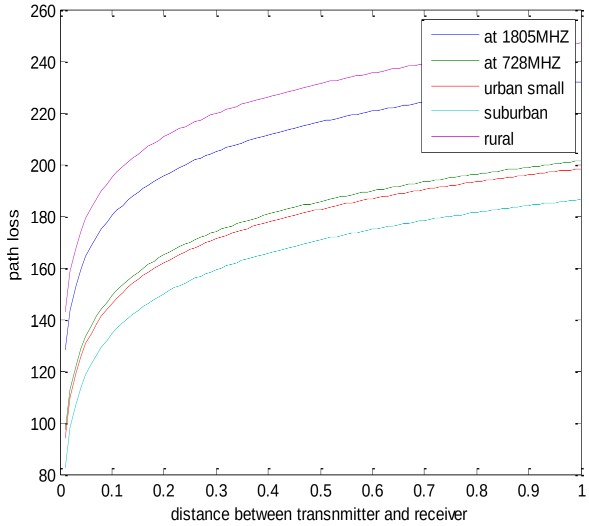

Figure: 4 Path loss and IFA (receiver height=1m)

Figure 4 shows the path loss versus distance between transmitter and receiver for different frequencies and for different mediums like rural, suburban, small urban etc. for all mediums the value of path loss increases as user moves away from the base station. In this simulation we have taken receiver antenna height one meter. In further simulation we will perform the same task by changing the height of receiver antenna height.

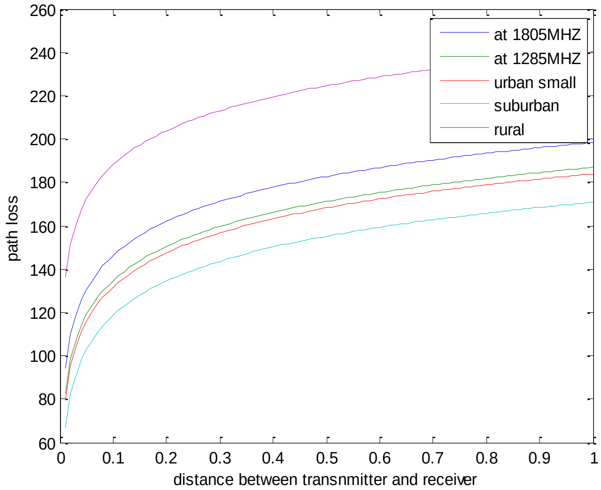

Figure:5 Path loss and IFA (receiver height=5m)

Figure 5 shows the path loss for different mediums when we taken antenna height of 5 meters. There is a decrease of 20-25 db in path loss in comparison to 1 meter antenna height.

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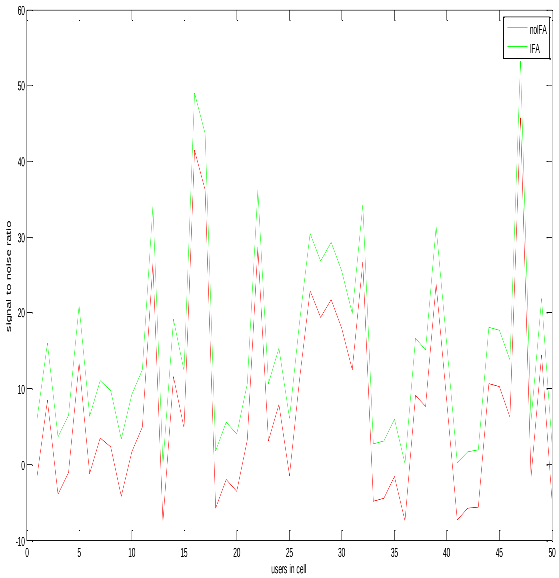

Figure 6: Improved SNR of users with IFA (f1=1285mhz,f2=1805mhz)

Figure 6 shows the signal to noise ratio for different users with or without IFA .it is clear from the simulation that there is about 5 db of gain in SNR with the proposed technique we have taken two frequency for cell centre and cell boundary .

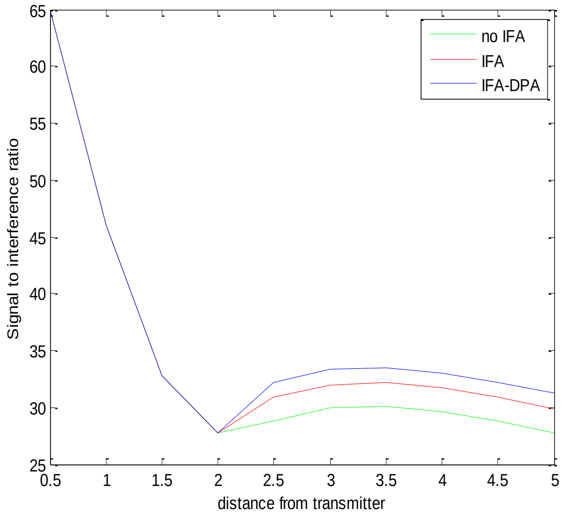

Figure:7 Improved SNR when user moves towards cell boundaries

Figure7 shows the simulation result of IFA, IFA-DPA.in this work different frequency bands are assigned for different location of a user in target cell .frequency allocation is depends upon the location whether a user is from cell Centre or from cell boundaries. Different transmitting power levels are also selected according to user location when user is at cell boundaries transmitting power level will be boosted to maintain the inter-cell interference and the signal strength .so as results shows that with IFA SNR is increased by a value of 3 db and this is increased about 5 db with IFA-DPA.

VII. CONCLUSION

Simulation models and cost-231 LTE propagation model systems design for proposed algorithm IFA-DPA have been discussed in this paper. Results of user mobility with in a cell and respective ICI are presented. Different parameters like transmitter and receiver height for different mediums and their effects on signal strength are simulated. The signal strength of random users are simulated with and without proposed algorithm. The performance analysis of simulation results is done for proposed approach. Finally, the performance of proposed approach IFA-DPA is carried out with other approaches like IFA.

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