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Comparative Analysis for Strategic Minimization of the Interference in Small Cell LTE Networks

Salah Boubkar Salah[1], Prinu.C.Philip[2], Rajeev Paulus[3] and A.K.Jaiswal[4]

[1]*M.Tech Student. Department of Electronics & Communication Engineering ,Sam Higginbottom University of Agriculture, Technology & Sciences"SHUATS", Allahabad-211007, India.*

[2]*Assistant Professor, Department of Electronics & Communication Engineering ,Sam Higginbottom University of Agriculture, Technology & Sciences" SHUATS", Allahabad-211007,India.*

[3]*Assistant Professor, Department of Electronics & Communication Engineering ,Sam Higginbottom University of Agriculture, Technology & Sciences" SHUATS", Allahabad-211007, India.*

[4]*Professor & Head of Department of Electronics & Communication Engineering ,Sam Higginbottom University of Agriculture, Technology & Sciences" SHUATS", Allahabad-211007, India.*

Abstract

Interference has been major issue in the heterogeneous Networks in LTE-A. The various network elements like macro-cells, pico-cell and Femto-cells are deployed to provide the wide range of the infra-structure. Thus, due to this heterogeneous deployment, need for the interference mitigation technique is required. In this work, ABSF has been studied and results have shown that its strategic implementation can improve the interference in HetNets and its effectiveness in different scenarios has been compared. In our proposed work, we have presented comparison of the various scheduling algorithms like Proportional Fair, Best CQI Scheduler and its effect in ABSF implementation. Thus, their spectral efficiency has been compared.

Keywords: Interference, HetNets, CQI, spectral efficiency,ABSF

INTRODUCTION

A heterogeneous network (HetNet) framework is known as one of optimum solutions to achieve very high rates in LTE-Advanced. A HetNet is a heterogeneous multi-network that consists many nodes. UEs,etc. different features, capabilities, and targets. These nodes are distributed along the wide infrastructure of the area of a macro-cell, and are allocated the same licensed spectrum allocated to the macro-cell, optimize the area latency and efficiency of the network.

Examples of these network nodes are femto-cells, pico-cells, relays, and remote radio heads (RRHs). The HetNet comprised of macro-cell and femto-cells.

Interference is the most disturbing element in deploying the networks. a basic feature for them, and hence the femto-cells will be a source of strong and unpredictable interference. ABSF is one of the proposed time domain techniques in the eICIC framework. In this paper, we have studied the overall structure and infrastructure based on ABSF to reduce the overall intercessions and congestions between the various node users and coverage area. We have studied the overall consequences of ABSF in different scheduling algorithms. Various scenarios have been studied under various influences. It is proposed to increase the network performance through the throughput improvement that improves the overall performance of the network.

INTERFERENCE IN LTE-NETWORKS

The simultaneous use of the same spectrum between different cell layers that run on different values of transmit power creates interference that will become more severe compared to homogeneous networks. For pico cells the interference does not create coverage hole due to open access to all UEs.

The situation is different for femto cell due to being equipped with the CSG feature that results into new and severe interference conditions.. There are two scenarios that create severe interference when macro UE (MUE) does not belong to femto cell CSG and being close to it Since MUE is power controlled by the macro cell, MUE will cause likely strong bursty interference to femto cell.

OVERVIEW OF e-ICIC TECHNIQUES

The eICIC techniques provide coordination in inter-cellular environment on the macro-femto deployment. The first solution is power control in which the HeNB adjust its transmission power to avoid interference to other. The second frequency-domain solution uses orthogonal bandwidth for control signaling. The last one is time-domain solution by stopping use some sub-frames the interfering node can reduce its downlink interference to the users. In power control approach, the power allocation can be determined based on some strategies such as the strongest receiving power of MeNB at the Femto, the pathloss between Femto base station and macro user MUE, the objective SINR of HUE, and the objective SINR of MUE. In frequency-domain solution, reduced bandwidth for control channels and physical signal, such that the control channels and physical signals can be totally orthogonal to those in another layer.

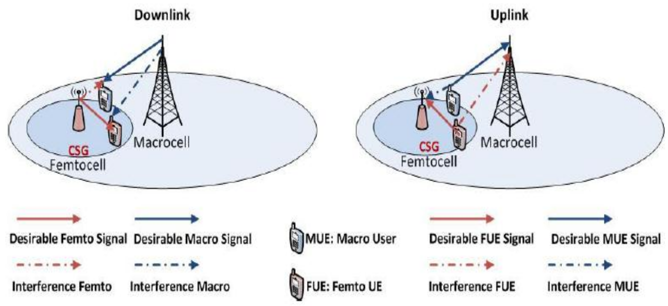

Figure 1: Downlink and Uplink Facilitation in Macrocell

In time-domain solution, some sub-frames called Almost Blank Sub-Frames (ABSFs) are muted at the interfering HeNBs, then the MeNB can schedule its downlink to the victim MUE in order to recover the signal quality of its user. The use of ABSF can help MUE recover its performance due to the strong downlink interference of HeNBs, in another side, the performance of the FUE serving by the interfering HeNB is reduced. Hence, the selection of number of sub-frames and which and when HeNB should start to mute are crucial in eICIC ABSF approach.

The key to achieve the desired latency and minimum interferences lies in the various mitigation strategies that is intelligent enough to optimize the power requirements bandwidth required for that particular applications. For scheduling based on OFDMA, it balances maximum throughput and fairness by scheduling time slots, sub-channels, modulation scheme and power with frequency diversity and multiuser diversity

Frequency diversity can be defined to distribute the time and frequency domain parameters to optimize the band allocation and frequency, due to shadowing, fast fading, multipath and so on.

In a similar way, multiuser diversity is obtained by opportunistic user scheduling, since different users locate different places leading to different channel gains of an identical sub-channel for different users. By analyzing CSI, base station recognizes variation of time, frequency, space and adjusts scheduling to keep optimal performance. Based on the architecture, for those UEs that have dual connectivity, the MeNB needs to decide how many downlink data that those UEs can receive from the connected SeNBs. While scheduling, if the MeNB arbitrarily transfers UEs' downlink

This technique can smooth out interference in this case, but it also decreases capacity at serving femto cell and increases interference to the neighboring cells. In case the MUE is closer to femto cell that the UE that is served by femto cell, noise padding cannot solve the problem and the UE served by femto cell would experience outage.

ABSF PATTERN

In our model for the resource partitioning between normal MUEs and VMUEs, the resources are partitioned in two stages. In the first stage all the MUEs of the macro-cell form two coalitions, one for the normal MUEs and the other for the VMUEs. the partitioning of resources again and hence the reduction of the blanking rate associated to each HIA. In this stage of resource partitioning, each coalition is assigned a part of the ABSF amount.

There may be a resource partition that is shared partially or completely between two coalitions, and thus the new resource partitions in the second level of bargaining may be overlapping. Hence Reduced ABSF Pattern associated with an offset to guarantee that the effective blanking rate seen by the macro-cell is the optimal and fair blanking rate decided in the first stage of bargaining.

An algorithm is proposed to select dynamically optimal ABSFs for each HeNB, and to group the interfering HeNB into coalition in order to decide which and where subframes should be muted by the interfering HeNB in each coalition. The muted rate at each HeNB is selected as minimum as possible to enhance the performance of the femto-cell UE users while satisfies the QoS of the macro users. The proposed algorithm firstly determine the required muted rate for each VMUE via ABSF selection mechanism. By applying the second mechanism called Interfering HeNBs Coaliation, the aggressor HeNBs are grouped into coalition, each aggressor HeNB with a different muted rate and time slot has to stop their transmission on time.

When the HeNB is marked as an aggressor HeNB, it will limitdeselecting some sub-frames to limit its interference to the victim MUE. Then the SINR m at link Lm between the MeNB and the macro user MUE m

$$\gamma_m = G(M,m)\,P(m) / \sum_{f\in F} P(E_f)G(F_f,m)(1-\alpha_m)+\sigma_m$$

where α_m is the muted rate required for macro user m during one radio frame . Our objectives are to find the muted rate to satisfy the required minimum SINR of the victim MUE.

$$\sum(\alpha_{m})$$

Minimize

$$\alpha_{m} \geq B,$$

Subjected to A

$$0 \leq \alpha_{m} \leq 1$$

RESULTS & DISCUSSION

In our work, we have considered the simulation of the Heterogeneous Networks. We have considered Macro/Femto Scenario to calculate the number of sub-frame to be blanked for given scenario in order to minimize the interference in such scenarios. ABSF Technique is used for blanking the sub-frames caused by the Femto- cells to users.

Table I. Simulation Parameters

Carrier Frequency	2.14 GHz
System Bandwidth	10MHz
eNBTx Power	46dBm-
FemtoTx Power	20dBm
Scheduler	Proportional Fair/ CQI
Transmission Scheme	2X2 MIMO
Macroscopic Pathloss Model	TS36942
Inter eNB distance	500m
Number of RBs	50

The Macro cell transmit the power is considered as 46dBm and the deployed Femto cell power is 20dBm.

- Proportional fair has been used
- path loss model used is TS36942
- The transmission scheme used is MIMO

Table II: Parameters Scenarios

Parameters	Scenario 1	Scenario 2	Scenario 3
Macro Cells	2	2	23
Femto Cells	1per Macro	2per Macro	1per Macro
Macro UEs	1per Macro	2per Macro	1per Macro
Femto UEs	1per Femto	2per Femto	1per Femto
Victim UEs	1	3	10
No.of ABS	14	18	20

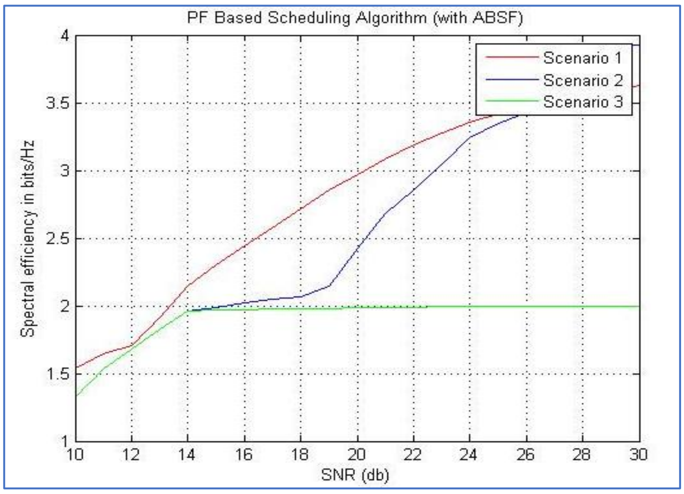

Figure 2: spectral efficiency of network with ABSF implemented with Proportional fair

Figure 2 is obtained through the simulation parameters as Table I. Here, spectral efficiency compared for all three scenarios with respect SNR with Proportional Fair being implemented

In case of scenario-1, spectral efficiency 1.5 bits/Hz for less than 10dB of power and increase almost linearly after that with respect the scenario 2. Similarly, the scenario 2, it starts from the efficiency of 1.3 bits/Hz and goes on increasing linearly with the SNR (dB).In case scenario 3, spectral efficiency constant after attaining a saturation value and does not depend on SNR(dB). Thus, in this case scenario 1 has the highest efficiency compared to scenario 2 and scenario 3.

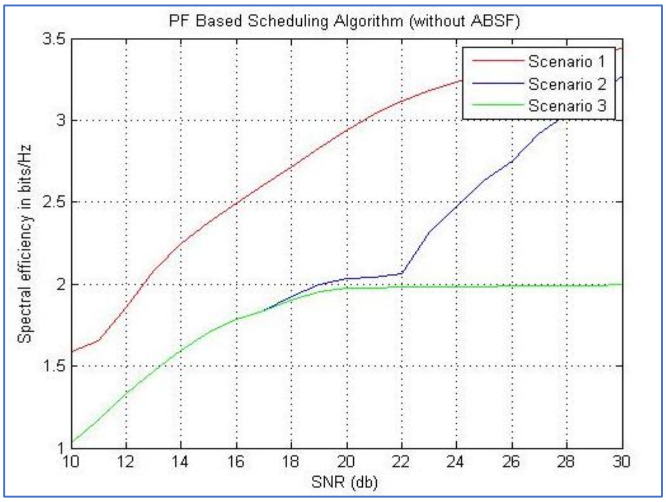

Figure 3: Spectral efficiency of network without ABSF implemented with Proportional fair

Figure 3 is obtained through the simulation parameters lies in Table I. Here, the spectral efficiency has been compared for all three scenarios with respect to SNR with Proportional Fair being implemented.

In case of scenario-1, spectral efficiency 1.6 bits/Hz for less than 11dB of power and goes on increasing after that. Similarly, scenario 2, it starts from the efficiency of 1 bits/Hz and goes on increasing non-linearly with the SNR (dB).In case scenario 3, spectral efficiency is constant at 2bits/Hz and does not depend on SNR(dB). after 20dB Thus, in this case scenario 1 has the highest efficiency compare to scenario 2 and scenario 3.

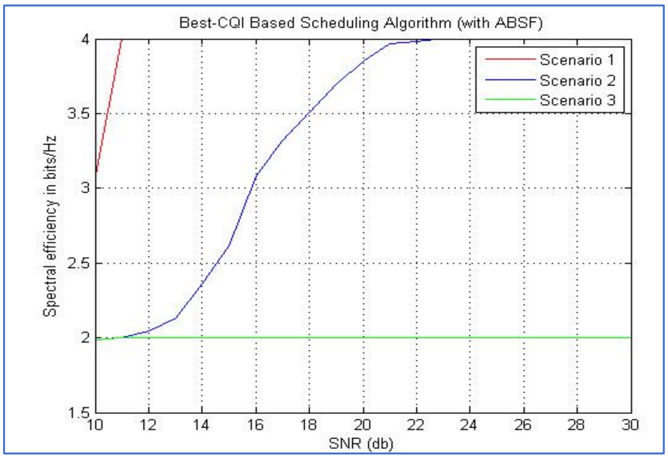

Figure 4: Spectral efficiency of network with ABSF implemented with Best CQI

Figure 4 is obtained through the simulation parameters in Table I. Here, spectral efficiency has been compared for all three scenarios with respect to SNR .In case of scenario-1, spectral efficiency 3.1 bits/Hz for less than 11dB of power and then increase linearly after that. Similarly, scenario 2, it starts from the efficiency of 2 bits/Hz and goes on increasing exponentially with the SNR (dB).In case scenario 3, the spectral efficiency is constant at 2bits/Hz and doesn't depend on the SNR(dB). Thus, in this case scenario 1 has the high efficiency compared to scenario 2 and scenario 3.

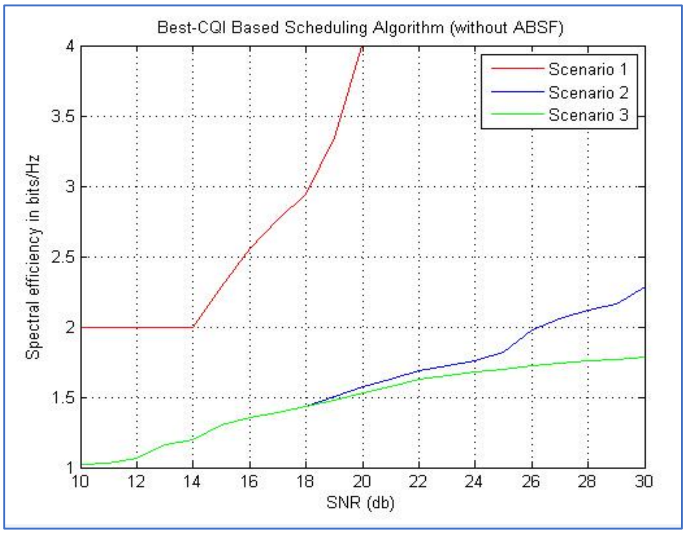

Figure 5: Spectral efficiency of network without ABSF implemented with Best CQI

Figure 5 is obtained through the simulation parameters in Table I. Here, spectral efficiency has been compared for all three scenarios with respect to SNR.

In this case, ABSF has not being implemented. In case of scenario-1, the spectral efficiency is constant upto14dB,and goes on increasing after this. Similarly, the scenario 2, it starts from the efficiency of 1 bits/Hz and goes on increasing linearly with the SNR (dB).In case scenario 3, the spectral starts with 1dB and goes on increasing till 18dB. After this, it follows the valley and almost remains constant. Thus, in this case scenario 1 has the high efficiency compared to scenario 2 and scenario 3. The efficiency of the scenario 3 becomes constant after a SNR of 22dB.

We thus have compared the two scheduling along with ABSF as: PF, Best CQI with MIMO. We found that spectral efficiency is increased with the effect of ABSF rather than without ABSF.

CONCLUSION

In this work, we have presented the detailed comparison of the ABSF technique for interference mitigation in various scenarios with various scheduling algorithm. The results have shown that ABSF tends to increase the spectral efficiency of the system in various scenarios. It has been shown that CQI algorithm outperforms the PF algorithms in implementing the ABSF. Efficiency has been increased and performs better in lesser SNR as well.

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