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Self-organized HGBBDSA Approach for the Power Allocation in OFDMA-based Heterogeneous Network

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Abstract

This paper studied the power allocation and downlink interference issues in orthogonal frequency-division-multiple-access (OFDMA) system to mitigate the interference issues. In Orthogonal Frequency Division Multiplexing Access (OFDMA) frameworks, resource allotment to the subcarrier is crucial attributable to the deficient assets accessible at the base station. In OFDMA, subcarrier and power distribution are not separate, along with these lines this two portion are not self-overseeing. This paper examines the power allocation approach through exploring the HGBBDSA approach. The integration of GA with Biogeography Based Optimization algorithm benchmarked over the Particle Swarm Optimization (PSO). The both of the algorithms cross usefulness is evaluated and looked at the exhibitions in Heterogeneous Network (HetNet). The reenactment results demonstrate that the HGBBDSA approach efficiently allocates the power than that of existing PSO approach.

Keywords: *OFDMA; Heterogeneous Network; LTE-A; HeNodeB*

1. Introduction

Long Term Evolution Advanced (LTE-A), reuses the spectrums to achieve maximum capacity and improving the radio system deployment. The HeNodeB's are small low-power plug and play base stations in HetNet, which is randomly deployed to extend the coverage in indoor [1]. The irregular implementation of HeNodeBs conveyed unplanned way, this, at last, makes the reason for Co-tier Interference (CTI) in HetNet. The CTI leads the system throughput degradation [2]. Therefore, the CTI management is the key issue in OFDMA based HetNets, which should have been tended to. In spite of the fact that a power administration strategy results from the CTI reduction from the network, and spectral reuse is the unique technique where out-of-cell transmissions influence CTI. Hence, CTI controlling has transformed into one of the significant issues in expanding correspondence framework limit. A typical CTI scenario represented in Figure 1. In LTE-A HetNet, the data transmission limit is extended by HeNodeBs, regularly for the indoor environment. A run of the HetNet engineering with HeNodeB has spoken to in Figure 1[1]. Figure 1 also demonstrates that the LTE and LTE-A frameworks incorporated into a typical HetNet, where various MUEs and HUEs are dynamic. Power control is one of the interference mitigation technique in HetNet OFDMA systems Likewise, authors stated a power control method through modeled an interference channel to relieve interference in a HetNet OFDMA systems [3]. Some studies investigated the power monitoring system by frequency scheduling, and dynamic resource partitioning [4-8]. For code-division different access frameworks, power control strategies are proposed in and for interference

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concerns [5] [6, 7]. However, the Intra-Cell Interference (ICI) issue is more intricate when a HeNodeB is suffering by an-other adjacent HeNodeB. A HeNodeB User (HUE) received adjacent HeNodeBs signal and caused the ICI when HUE is in the coverage of the adjacent HeNodeB because the adjacent HeNodeB's transmission power is much stronger than the serving HeNodeB. To maintain the required signal-to-interference-plus-noise ratio, the HUEs force limitations on gathered interference, which is combined power allocation constraints for the HeNodeBs. As the interference management is the key concern in OFDMA based Het-Net, many researchers have investigated by presenting power control and power distribution by cooperative and non-cooperative game theory [8, 9]. The central concepts of the non-cooperative game theory are to maximize the utility by a selfish base station with-out considering any other. On the other hand, the cooperative game theory allows the utility maximization by sharing with other base station. Therefore, the co-operative proposals are more suitable concepts concerning power allocation. The other work had presented the Differential Evolution (DE), Particle Swarm Optimization (PSO), and Genetic Algorithm (GA) to allocate the power among the HeNodeBs to manage the interference and maximize the throughput as well[10, 11]. However, this paper is going to present a Hybrid Genetic with Biogeography based Optimization algorithm to mitigate the Intra-Cell Interference (ICI) dynamically (HGBBDSA-ICI). The main this study mainly analyzed the power allocation in HetNet thorough HGBBDSA-ICI approach.

The rest of the paper is structured as: section 2 presents the related works. Section 3 converses the co-tier interference model for the heterogeneous network. Section 4 evaluates the presentation of the HGBBDSA-ICI based dynamic subcarrier allocation approach. Section 5 accomplishes summary of the paper.

2. System Model

The HeNodeB with MUE interference issue is considered to form up the model. The key thought of this model is to seek the unused subcarriers and after that reuse those among the MUEs. In this model, the power allocation is engaged. To do as such, the multi-client OFDMA framework system block is spoken to in Figure 2. The OFDMA resource allocation is impelled through the OFDM transmitter. The transmitter right then and there indicates distinctive quantities of bits from various clients to prepare an OFDM symbols. The power allocation in OFDMA is then dynamic as quick as the channel data is processed.

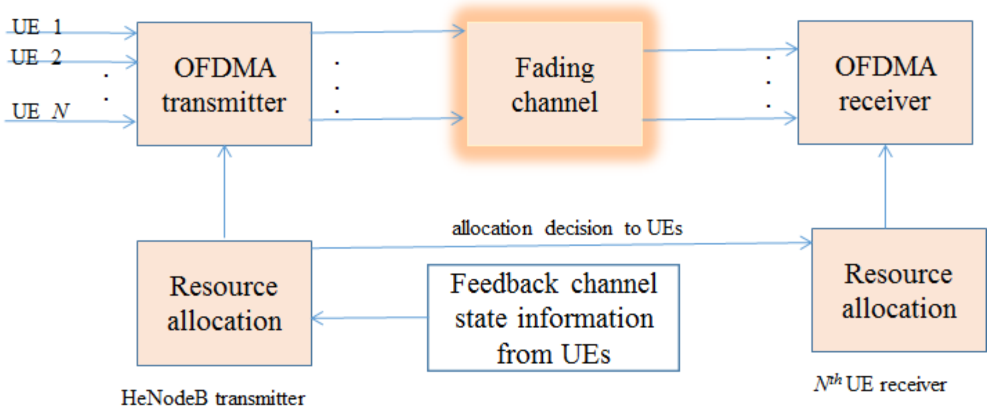

Figure 2. Multi-User OFDMA System Block Diagram [12]

The power allocated to each of the users comprehensively in neighbor HeNodeBs. The HeNdoeB and macro-eNodeB layers ensures intra-cell orthogonality among its mobile users. Mathematically, we impose generalized interference temperature constraints [12] on the FBSs' transmission power. The mathematical derivation of SINR considering, ICI situation is given in Eqn. 1. The SINR at HeNodeB and MUE can be expressed as:

$$\mathcal{S}_{u_m,Z}^{SINR} = \frac{p_z^{MUE_i} \times \vartheta_{\mathrm{MUE}\leftrightarrow\mathrm{M}} \times \left|\mathcal{H}_M^{MUE_i}\right|^2 \times D_M^{MUE_i}}{\sum_{i_n\in J_{int,z}}^{Z}\left|h_{j_n,z}^{u_m}\right|^2 p_z^{j_n}\vartheta_{\mathrm{MUE}_i\leftrightarrow H_j} D_{MUE_i\leftrightarrow M}^{MUE_i} + \sum_{i_n\in i_{int,z}}^{Z}\left|\mathcal{H}_{H_j,z}^{j_n}\right|^2 p_z^{u_m}\vartheta_{\mathrm{MUE}_i\leftrightarrow H_j} D_{MUE_i\leftrightarrow H_j}^{MUE_i} + N_0} \tag{1}$$

Using Shannon's law, the capacity can be stated as:

$$\hbar_{s,i} = \sum_{s=1}^{S}\frac{a_{i,s}}{S}\log_2\left(1+\mathcal{S}_{u_m,Z}^{SINR}\right) \tag{2}$$

In order to enhance as per the fitness constraint, the subcarrier optimization problem can be shown in Eqn. 3.

$$Max\left(\overline{W_{\iota,S}}, p_z^{i_n}\right) = \sum_{i}^{I} a_{i,z}\sum_{s=1}^{S}\frac{a_{i,s}}{S}\log_2\left(1+\mathcal{S}_{u_m,Z}^{SINR}\right) \tag{3}$$

where, $a_{i,z}$ presents the weight factor, and $\overline{W_{\iota,S}}$ denoted the allocated subcarrier which is now known. However, as this paper focused only power allocation, the Eqn.4 derives the optimization problem for the power allocation with its constraints.

$$Max\left(\overline{W_{\iota,S}}, p_S^{i_n}\right) = \sum_{i}^{I} a_{i,z}\sum_{s=1}^{S}\frac{a_{i,s}}{S}\log_2\left(1+\mathcal{S}_{u_m,Z}^{SINR}\right) \tag{4}$$

Subject to:

$$\sum_{i}^{I}\sum_{s=1}^{S} p_S^{i_n} \le P_{total}$$

$$p_z^{i_n} \ge 0, \quad i = 1,2,3.4,\ldots..I, and\ s = 1,2,\ldots,S$$

Applying KKT multiplier, the power can be estimated as below:

$$\frac{\partial L}{\partial p_S^{i_n}} = \frac{h_{s,i}}{1+p_S^{i_n}h_{s,i}} - \alpha \le 0 \tag{5}$$

$$p_S^{i_n}\left(\frac{h_{s,i}}{1+p_S^{i_n}h_{s,i}} - \alpha\right) = 0, \qquad s = 1,2,..,S, \qquad i = 1,2,\ldots I$$

$$\alpha\frac{\partial L}{\partial \alpha} = 0 \tag{6}$$

As $p_S^{i_n} \ge 0$, then

$$\frac{h_{s,i}}{1+p_S^{i_n}h_{s,i}} - \alpha = 0, \sum_{i}^{I}\sum_{s=1}^{S} p_S^{i_n} - P_{total} = 0 \tag{7}$$

Therefore, the power can be estimated by using Eqn. 8.

$$p_S^{i_n}\left(\overline{W_{\iota,S}}\right) = \frac{P_{total} + \sum_{s=1}^{S}\left(\frac{\overline{W_{\iota,S}}}{I}\right)\sum_i^I\sum_{s=1}^{S} h_{s,i}}{S \times I} - \frac{1}{h_{s,i}} \tag{8}$$

3. Power Allocation Framework

The proposed biogeography based approach predominantly utilizes natural surroundings of biogeography indicates a hopeful streamlining arrangement, and it comprises of an accumulation of geologies which are said to as choice variables or independent variables.

A pool of natural biogeography surroundings demonstrates a populace of conceivable arrangements. Territory reasonableness file in the biogeography alludes to the wellness of a conceivable method. An applicant arrangement inside BBO[13] offers choice variables probabilistically with other hopeful answers for improving arrangement wellness of competitor. This procedure of sharing identified with movement in biogeography. Therefore, an applicant agreement moves the choice variables and other conceivable method utilizing the migration rates, and also emigrates choice variables to other conceivable methods relying upon its resettlement rate. The methodology is as per the following:

- Initially it produces a gathering program as population.
- Estimates the wellness of the system by applying the biogeography movement with the connection of exiled people and the migration rates.
- Make a qualification of the movement proportions from the exiled person's pools (HeNodeB).
- Generate the numerous posterity and after that encode and change the hybrid.
- Assessments the state of projects wellness by applying the wellness advancement.
- Share the projects among the pools (*i.e.*, HeNodeBs)
- Start the technique of re-era and take after the progression 1 to 6

The objective of change is to raise collection inside the populace. These discretionary events in BBO, the HSI of common environment can change rapidly. Hence, in BBO, the change of HIV happens. Plans with high HSI and low HSI are both comparatively dicey, however the ordinary HSI techniques are about straightforward to change. The power allocation can proficiently finish by applying the above strides.

4. Result Discussion

In view of subcarrier allocation, the consequences are simulated, where 35 HUEs, 35 HeNodeBs are considered. For PSO based subcarrier allocation is the 500 number of processes are iterated. The simulation is completed utilizing MATLAB based test system. The reenactment parameters are recorded in Table 1[2, 3, 14, 15].

Table 1. LTE-A Henodeb Operation Specification

Description	Specification
Frequency band	2.6 GHz
Number of HeNodeBs	50
Bandwidth	20MHz
No. of subcarriers	720
HeNodeBs distance	20m
macro-eNodeBs' transmission power	46 dBm
HeNodeBs' transmission power	23dBm
Penetration wall loss	20dB
Inter-site distance	500m
Thermal noise factor	-174 Bm/Hz
shadowing correlation	0.7dB
Number of HUE	35
SINR threshold	-8dB
Exponent factor	3
Modulation	64QAM
Sub frame time duration	1ms
Apartment dimension	10 x $10m^2$
BER	10^{-6}
Pathloss	$15.3 + 37.6\log_{10}(d) + \ell_W$
Channel gain	$\lvert h_{q,s}^{j_n}\rvert^2\ 10^{(-\ell\,(d)+Ye)/10}$
Fading	Rayleigh

Population	500
Generation	500
Mutation factor	0.015
Immigration rate	1

The simulation scenario is shown in Figure 3. Where macro-eNodeB, HeNodeB, HUEs and MUEs are considered.

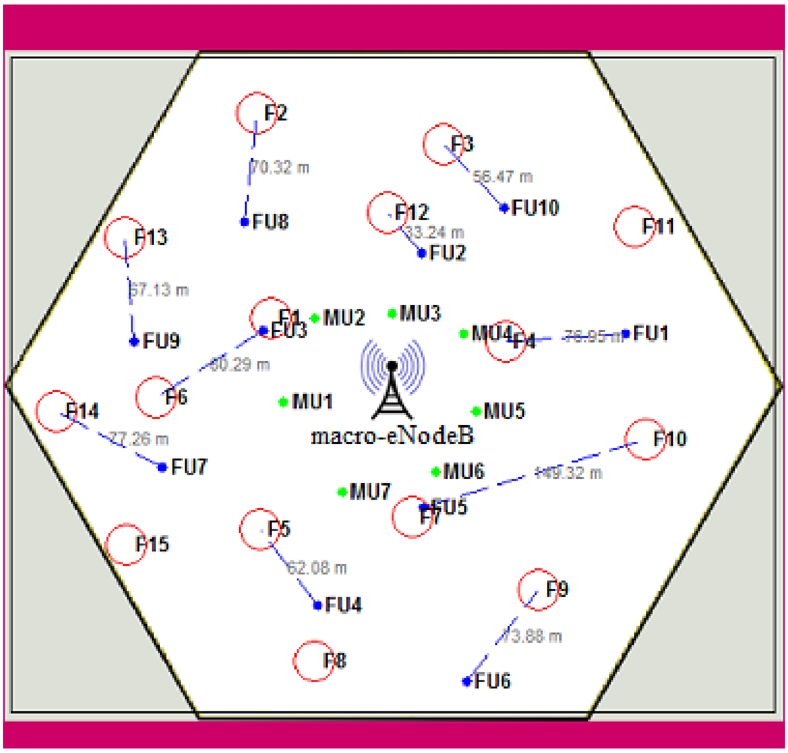

Figure 3. Simulation Scenario, Where FU Indicates HUE, MU Indicates as MUE, and F States Henodeb

Figure 4. shows the transmit power over the signal to noise ratio. Figure suggests that the proposed approach has the lower power transmit compare with the existing PSO based allocation. Figure 5 presents the transmit power over the number of users. It is seen that if the number of users increases then the transmit power also increases. The proposed approach transmits less than 12 dBm for 10 number of users, while PSO based approach transmits 13dBm power for the same number of user. It is also shows that, the power variance for the different number of user is very small also.

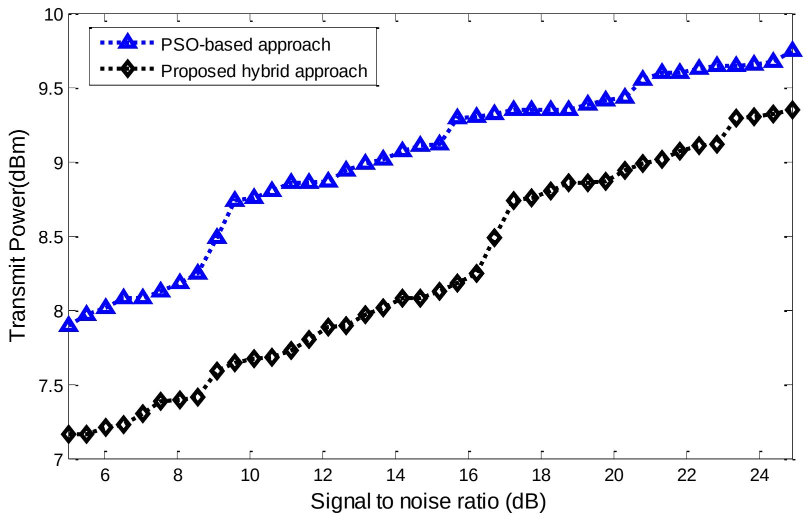

Figure 4. Transmit Power vs. Signal To Noise Ratio

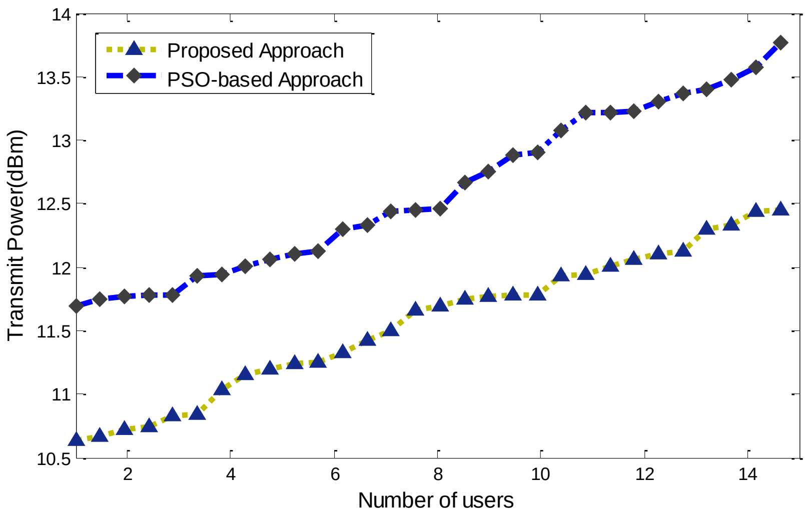

Figure 5. Transmit Power vs. Signal To Noise Ratio

Figure 6 demonstrates total power allocation of the proposed approach. The power allocation is accomplished with the proposed algorithms number of iteration. It is shown that the 0.68 dBm power is allocated to the users while the number of iteration is 20. Meanwhile, with the 450 iterations, the power allocation is around 0.3dBm. In every iteration, the proposed algorithms check the system power allocation model and the HeNodeBs allocating power. Therefore, it can recommend that the proposed approach can allocate the minimum power so that the ICI can be mitigated in the heterogeneous network.

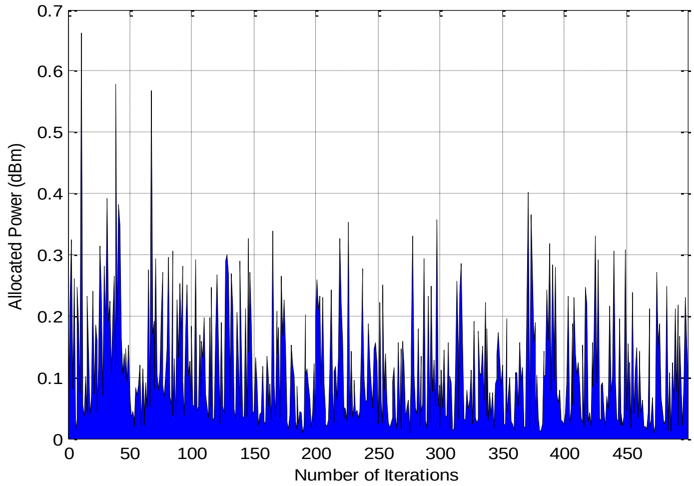

Figure 6. Transmit Power vs. Signal to Noise Ratio

Figure 7 demonstrates performance of the total capacity, where the proposed approach and PSO based approach with a progression of the SINR is composed. If the SINR increase then the total capacity also in-creased. So the overall system rate can also increase.

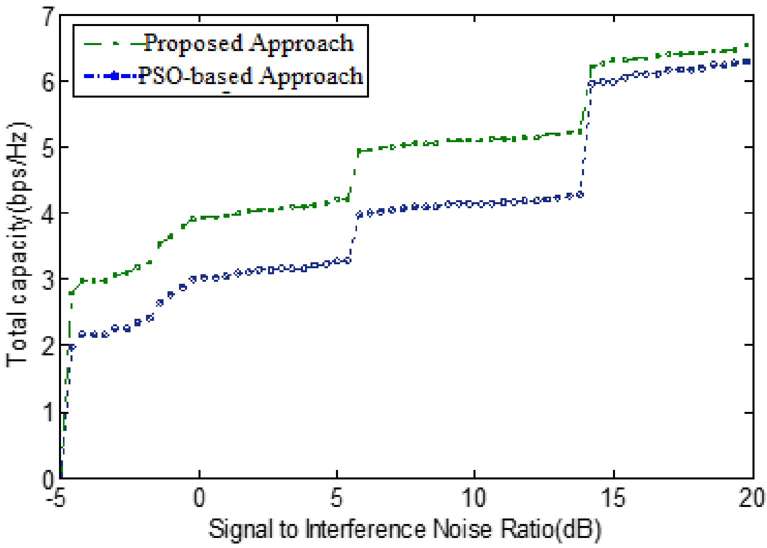

Figure 7. Total Capacity vs. Signal to Interference Noise ratio

5. Conclusion

This paper researched the interference issues in OFDMA based heterogeneous system. Various power assignment method is reviewed as far as interference mitigation. It has been apparent that the throughput interruption is brought about by interference. This paper analyzed the interference problem mathematically. It is also have come out with a proposal of the power allocation approach in OFDMA to mitigate the interference issues in Heterogeneous network. Which dissected the interference challenges with some potential strategies to moderate the total capacity and also boosted the system bitrates. This study recommends that the enhanced approach can enhance system performance such as the capacity, and power allocation with less power transmission. The future research will focus on joint subcarrier allocation and power allocations in OFDMA HetNets.

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