VOL. 10, NO. 21, NOVEMBER 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

THROUGHPUT EVALUATION FOR THE DOWNLINK SCENARIO OF CO-TIER INTERFERENCE IN HETEROGENEOUS NETWORK

Mohammad Kamrul Hasan[1], Ahmad Fadzil Ismail[1], Aisha-Hassan Abdalla[1], Wahidah Hashim[2] and Shayla Islam[1]
[1]Departmental of Electrical and Computer Engineering, International Islamic University Malaysia
[2] College of Information Technology, University Tenaga Nasional, Malaysia
E-Mail: hasankamrul@ieee.org

ABSTRACT

To extend the coverage and capacity of Heterogeneous Networks (HetNets), femtocells (HeNodeBs) has been impressive to deploy in in-house or apartment. Owing to co-channel spectrum involvement these HeNodeB sources Co-Tier interference (CTI) with neighbor HeNodeBs and users of HeNodeB (HUE) in orthogonal frequency division multiplexing Access (OFDMA). As a result, CTI is occurred which causes of system throughput degradation. This paper investigates the OFDMA subcarrier allocation techniques and algorithms. A Genetic Algorithm based Subcarrier Allocation (GA-SA) framework is evaluated to enhanced throughput of HeNodeB and HUE. The enhancement of the system throughput and Signal to Interference Noise Ratio (SINR) is analyzed to mitigate CTI. The system level simulation is considered to evaluate the performance of the framework. The results show that the throughput is enhanced for HUE and HeNodeB, which can mitigate the CTI in OFDMA.

Keywords: OFDMA, LTE/LTE-A, heterogeneous network, HeNodeB, subcarrier allocation, GA-S.

INTRODUCTION

Due to extreme demand of recent mobile communication and extending coverage on wireless cellular communication HetNet [1-3] has been introduced through deploying HeNodeB in indoor. The goal behind the implementation of HetNet involves incrementing the capacity, modifying spectrum use, lowering the capital and operating costs, as well as offering steady user-based experience of network architecture. In figure 1 the architecture of HetNet with the deployment of HeNodeB is illustrated. Afterward, it has been standardized by Third Generation Partnership Project-Long Term Evolution Advanced (3GPP-LTE-A) [4-6]. However, in an investigation for interference issues in LTE-A HetNet has found that the random HeNodeB deployments on HetNet raises CTI interferences which consequences the degradation overall performance [3], [7].

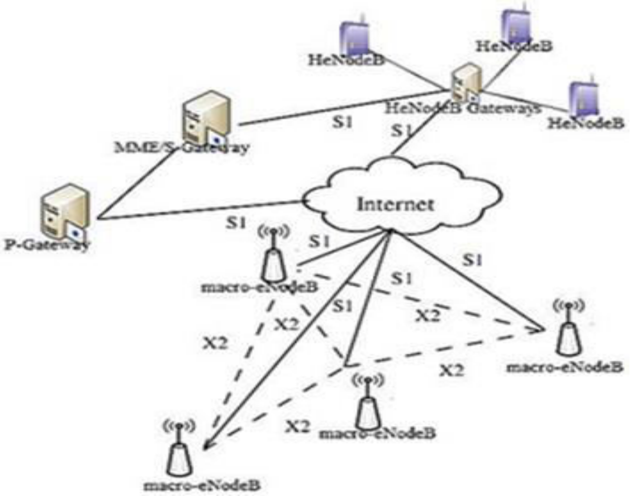

Figure-1. Structural design of HetNet.

In HetNet. HeNodeB with macro-eNodeB are facing CTI. The CTI is occurred concerning the HeNodeBs [7]. In the shared channel environment of the HeNodeB and macrocell, the overall performance can be embarked by allocating channels and powers levels in a cooperative manner, with the concern of minimizing both the interferences as shown in Figure-2.

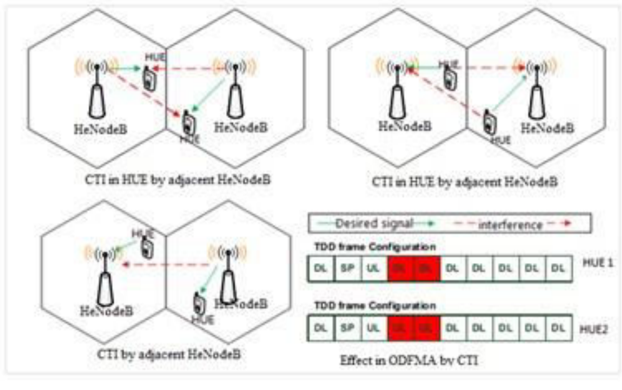

Figure-2. CTI scenarios in adjacent HeNodeB.

On one hand, the transmission power of the HeNodeB is a function of capacity, but on the other hand, increased power results in interferences on other channels, which results in reduced throughput. Resource allocation has been in many research which includes wireless communications. For the subcarrier allocation in OFDMA based HetNets, many of the algorithm has been proposed namely, ant colony, dynamic programming, greedy algorithms, graph theory, game approach.[8-10]. The Hungarian algorithm has been proposed to allocate the subcarriers in OFDMA [11], which is manly, utilized for the centralized approach. The outage and power ratio were considered as the performance metrics.

The authors in [12]investigate the self-organizing femtocells. They proposed the joint power allocation and dynamic resource allocation by exploiting the concepts of cognitive radios in femtocells, specifically in the decentralized manner. Actually, the authors combine the proposed game theory based resource allocation with fractional power control. The decentralized interference management is proposed in, where game theory is also employed in the non-cooperative environment. In [14], the authors proposed GA based centralized resource allocation in HeNodeBs, to maximize the throughput. The GA based resource allocation had considered to improve the system throughput in terms of interference mitigation, under the assumption of coordination among HeNodeB and macro-eNodeB. Hence, the resource allocation such as subcarrier allocation is one of the way to improve the system throughput in HetNet. To mitigate the CTI in HetNet, researchers had proposed power control as well as resource allocations especially considering HeNodeBs. This is to increase the throughput in terms of mitigating CTI. The authors [14] had proposed Genetic Algorithm (GA) and Particle Swarm (PSO) based resource allocation approaches. These approaches has used in order to exploit resource allocation issues. Moreover, authors [14] has also used heuristic algorithms in a decentralized manner to ensure the faster convergence. In consequences, the algorithms had designed following the impression of niching in the form of decentralization by sharing solutions within HeNodeBs. The target solutions are updated CTI victim HeNodeBs and HUEs nearby. However, in this paper the GA based subcarrier allocation algorithm will be focused in order to evaluate the performances of throughout, convergence.

The rest of the paper organizes as: section two represents the system model and problem formation, section three analyse the results with discussion and the paper concludes in section four.

SYSTEM MODEL AND PROBLEM FORMATION

The GA-based subcarrier allocation framework is composed for the HetNet especially under laid HeNodeB Network. Due to the same channel utilization, CTI deteriorated the throughput of HeNodeBs. Therefore, to mitigate such type of interference considering the CTI, the framework is depicted in Figure-3. In the framework, HeNodeBs are connected through internet broadband to the operator's management server. The GA-based subcarrier allocation optimization algorithm is performed the optimizing task in a decentralized way within the neighbor HeNodeBs and with the coordination of neighbor HeNodeBs which consequences in ideally allocating the subchannels to HUE and allocation of power to HeNodeB in LTE-A HetNet. Since, OFDM subchannel and power allocation is optimization problem. Following the Figure 3, the association of the jth HeNodeB and ith HUEs are having CTI. Hence, the SINR at HeNodeB can be represented in Equation 1.

$$\Upsilon^{SINR}_{i_n,s} = \frac{p_s^{i_n}\,\vartheta_{i_n}\,\left|h^{j_n}_{q,s}\right|^2 d_{j_n}^{-\vartheta_{i_n}}}{I_s^{i_n} + \Delta f\,\sigma^2} \quad (1)$$

$$I_s^{i_n} = \sum_{i_n\in J_{int,s}}^{S} \left|h^{j_n}_{j_n,s}\right|^2 p_s^{j_n} + \sum_{i_n\in i_{int,s}}^{S} \left|h^{i_n}_{i_n,s}\right|^2 p_s^{i_n}$$

Applying the Shannon's capacity law in Equation 1, we get the capacity in Equation 2.

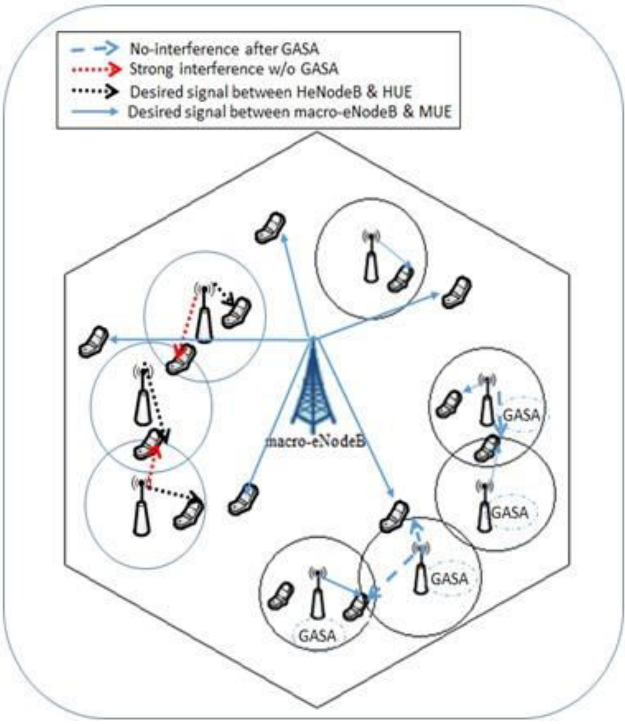

Figure-3. GA-based subcarrier allocation framework.

$$C_{s,i} = \sum_{s=1}^{S} \frac{a_{i,S}}{S} \log_2\left(1 + \Upsilon^{SINR}_{i_n,s}\right) \quad (2)$$

So, the optimization problem can be represented in Equation 3

$$Maximize\left(Q_{i,S}, p_s^{i_n}\right) = \sum_{i}^{I}\sum_{s=1}^{S} \left(a_{i,S}\, C_{s,i}\right) \quad (3)$$

The channel model is represented in Equation (4).

$$C^{i,S}_{j_n,S} = \left|h^{j_n}_{q,s}\right|^2 10^{(-L(d)+Le)/10} \quad (4)$$

The path-loss model [24]is considered as the type of links in between HUE and HeNodeB [15]. Taking in consideration of CTI in between HUE and HeNodeB

When considering the useful/interfering link between the path-loss estimation can be expressed in Equation (5) [15].

$$\vartheta_{i_n}[dB] = 15.3 + 37.6\log_{10}(d) + L_W \quad (5)$$

where the wall penetration in indoor L_W is the wall penetration loss (in dB), Le is the path-loss exponent and *d* (m) is the distance. This is how to model the LTE-A evaluation system.

GA-based subcarrier allocation

The framework of GA-based subcarrier allocation follows the steps as below point-wise:

1. At the beginning the algorithm generates a group of subcarrier allocation program.
2. Evaluate the fitness of the subcarrier using.
3. Select the subcarriers and mutate the crossover subcarriers.
4. Check the condition of subcarrier fitness (see Equation 3)
5. Share the subcarriers.

The flowchart of the GA-based subcarrier allocation is represented in Figure-4.

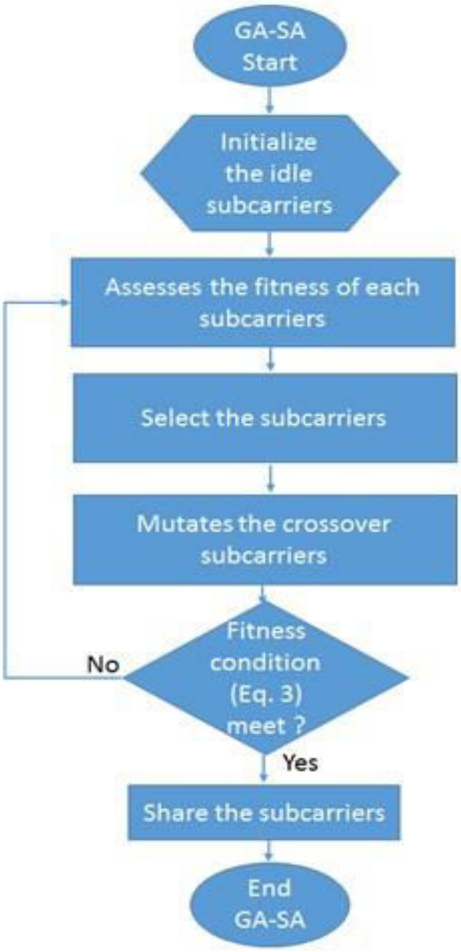

Figure-4. GA-based subcarrier allocation.

In the GA-based algorithm the set of subcarrier is observed as a population and the system rate is the fitness of each individual. The GA-based algorithm is focused with the performance metrics of average objective function, min–max throughput of the HeNodeBs, average throughput of the HUE.

RESULTS AND DISCUSSIONS

The simulation is carried out using MATLAB based simulator. The simulation parameters are listed in Table-1.

Table-1. LTE-A HeNodeB operation specification.

Description	Specification
Frequency band	2.6 GHz
Number of HeNodeBs	50
System Bandwidth	20MHz
Number of subcarriers	720
Distance between HeNodeBs	20m
Transmission power of macro-eNodeB (P_{tmax})	46 dBm
Transmission power of HeNodeB(P_{tmax})	23dBm
external wall loss *Le*	10dB
internal wall loss *Li*	0dB
Thermal noise factor σ^2	-174 Bm/Hz
shadowing correlation	0.7dB
Number of $_{MUE}$	50
SINR threshold P_λ	-8dB
penetration loss	5dB
Exponent factor α	3

Considering subcarrier allocation, the result for throughput is simulated. The result of objective function for GA based subcarrier allocation is shown in Figure-5 where 500 number of process is iterated.

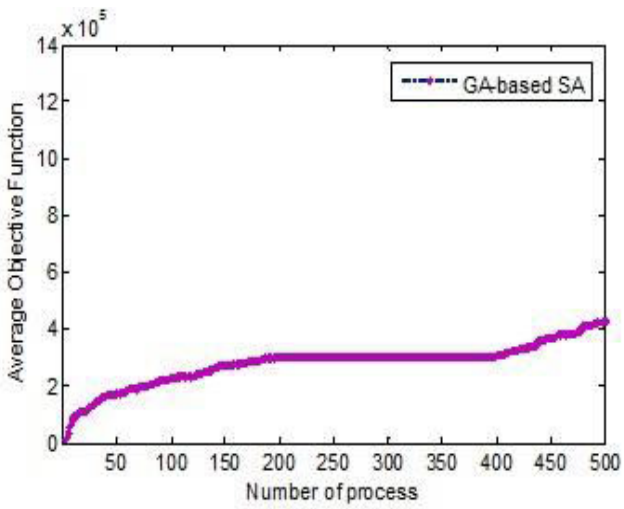

Figure-5. Representation of objective function vs number of process.

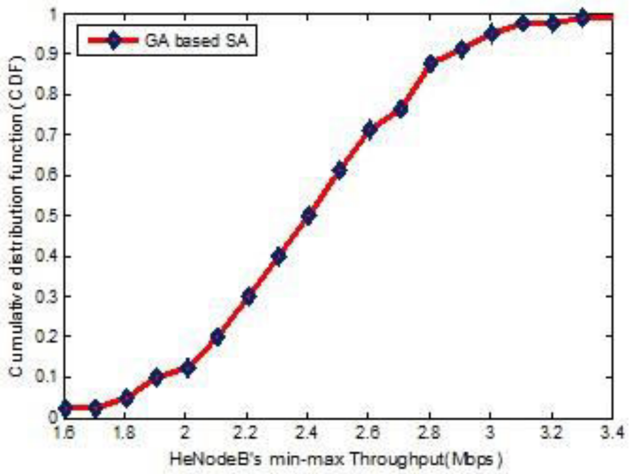

Figure-6. The performance of Min-max throughput

The average objective function is the key for maximization of throughput. It is observed that, by the subcarrier allocation the coverage is highly maximized which will impact on achieving the throughput. For the min-max throughput for HeNodeB subcarrier allocation, the Cumulative Distribution Function (CDF with respect to achieved throughput) is shown in Figure-6. It is noticeably highlighted that the throughput is maximized when the impact of the HeNodeBs are less. It is highlighted that the throughput is maximized up to 3.4 Mbps. In Figure-7 shows the average throughput of HUE, where the initial average throughput for the HUE can be achieved up to 2500 Kbps while 8 channels, also 1800 Kbps approximately. When the number of HUEs are increased, denser and already start to occupy with the subcarriers then throughput goes slowly down.

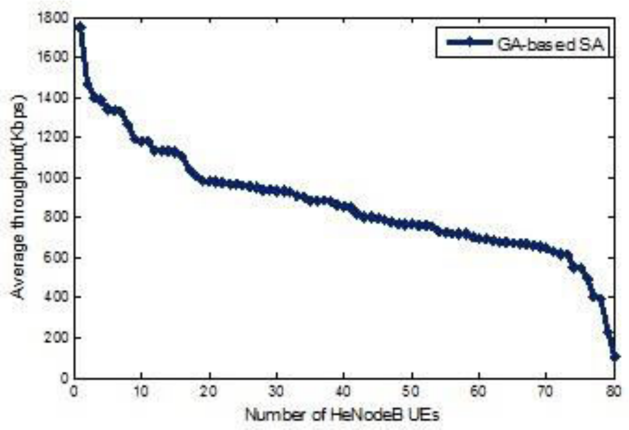

Figure-7. Average throughput vs. HUE.

CONCLUSIONS

This paper presented the co-channel deployment challenges in OFDMA based Heterogeneous Network. Moreover, it also formalize the co-tier interference problem model. Finally, paper evaluates the GA based subcarrier allocation to mitigate co-tier interference. It can be seen from the result analyses that GA can greatly improve the convergence and system throughput. However, the optimization algorithm can be enhanced in multilevel optimization algorithm to achieve the higher throughput.

ACKNOWLEDGEMENT

Author acknowledges with thanks to Ministry of Education for the education sponsorship, and appreciations to International Islamic University Malaysia (IIUM).

REFERENCES

[1] M. Hasan, A. F. Ismail, A. H. Abdalla, K. Abdullah, H. Ramli, S. Islam, *et al.*, "Inter-cell interference coordination in LTE-A HetNets: A survey on self organizing approaches," in Computing, Electrical and Electronics Engineering (ICCEEE), 2013 International Conference on, pp. 196-201.

[2] M. K. Hasan, A. F. Ismail, A.-H. Abdalla Hashim, K. Abdullah, and H. Ramli, "Performance analysis of interference coordination techniques in heterogeneous network," Research Journal of Applied Sciences, Engineering and Technology, vol. 7, pp. 1536-1550.

[3] M. K. Hasan, A. F. Ismail, H. Aisha, K. Abdullah, H. Ramli, S. Islam, *et al.*, "Inter-cell interference coordination in Heterogeneous Network: A qualitative and quantitative analysis," in Communications (MICC), IEEE Malaysia International Conference on, 2013, pp. 361-366.

[4] M. 3GPP R4-100207, ": Release 10 UE PUCCH/PUSCH configuration," ed, 2010.

[5] A. Damnjanovic, J. Montojo, Y. Wei, T. Ji, T. Luo, M. Vajapeyam, *et al.*, "A survey on 3GPP heterogeneous networks," Wireless Communications, IEEE, vol. 18, pp. 10-21.

[6] D. Martín-Sacristán, J. F. Monserrat, J. Cabrejas-Penuelas, D. Calabuig, S. Garrigas, and N. Cardona, "On the way towards fourth-generation mobile: 3GPP LTE and LTE-advanced," EURASIP Journal on Wireless Communications and Networking, vol. 2009, p. 4.

[7] D. Hu and S. Mao, "On co-channel and adjacent channel interference mitigation in cognitive radio networks," Ad Hoc Networks, vol. 11, pp. 1629-1640.

[8] N. A. Odhah, M. I. Dessouky, W. E. Al-Hanafy, and F. Abd El-Samie, "Low complexity greedy power allocation algorithm for proportional resource allocation in multi-user OFDM systems," Journal of Telecommunications and Information Technology, pp. 38-45.

[9] R. Y. Chang, Z. Tao, J. Zhang, and C. C. J. Kuo, "Dynamic fractional frequency reuse (D-FFR) for multicell OFDMA networks using a graph framework," Wireless Communications and Mobile Computing, vol. 13, pp. 12-27.

[10] S.-Y. Lien, Y.-Y. Lin, and K.-C. Chen, "Cognitive and game-theoretical radio resource management for autonomous femtocells with QoS guarantees," Wireless Communications, IEEE Transactions on, vol. 10, pp. 2196-2206.

[11] A. Abdelnasser and E. Hossain, "Subchannel and power allocation schemes for clustered femtocells in two-tier OFDMA HetNets," in Communications Workshops (ICC), IEEE International Conference on, 2013, pp. 1129-1133.

[12] C. H. De Lima, M. Bennis, and M. Latva-aho, "Coordination mechanisms for self-organizing femtocells in two-tier coexistence scenarios," Wireless Communications, IEEE Transactions on, vol. 11, pp. 2212-2223.

[13] da Costa, Gustavo WO, *et al*. "Interference mitigation in cognitive femtocells." GLOBECOM Workshops (GC Wkshps), IEEE.

[14] A. Shahid, S. Aslam, and K.-G. Lee, "A Decentralized Heuristic Approach towards Resource Allocation in Femtocell Networks," Entropy, vol. 15, pp. 2524-2547.

[15] 3GPP, "Simulation Assumptions and Parameters for FDD HeNB RF Requirements," 3GPP TSG RAN WG4 R4-092042, May 2008, http://www.3gpp.org/ftp/Specs.

[16] Sareni, B., & Krähenbühl, L. (1998). Fitness sharing and niching methods revisited. Evolutionary Computation, IEEE Transactions on, 2(3), 97-106.