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Resource Allocation Model and Power Control in Macrocell-Femtocell Networks by LA Algorithm

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Resource Allocation Model and Power Control in Macrocell-Femtocell Networks by LA Algorithm

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***Abstract*—**In the macrocell-femtocell HetNets, FBSs and its deployment are set up by users unknowning to to (MBS), thus, the inter-cell interference defines the power allocation, subcarrier assignment or allocation and price allocation as well. This paper further scrutinize cross-tier interference mitigation in FD-OFDMA based HetNets consisting of macrocell -femtocells. Conventionally, these three allocation problems (Power, Subcarrier and Price) were taken as separate constraints on macrocell and femtocell networks and optimized individually by defining as triple optimization strategy. In this paper three major contributions will be subjected: defining a single objective problem that includes three constraints like power allocation, subcarrier assignment or allocation and price allocation of Macro-Femto Networks, as the work concentrates on the optimization logics, the solution encoding process seems to be the most important aspect; this paper introduce a new encoding transformation model of all the three allocation strategies, introducing the concept of Lion Algorithm (LA algorithm are required to solve the above mentioned optimization problem in Macrocell-Femtocell Networks. Finally, the performance of algorithm will be compared over the state-of-the-arts models concerning convergence and statistical analysis.

Keywords—Resource Allocation; Heterogeneous Networks; Power Allocation; Lion Algorithm.

I. INTRODUCTION

Femtocells [9] [10] [11] are considered as a low-power access points that provide the probability of h high-quality network access with low cost for the indoor users. In architecture, Femtocells might superimpose within Macrocells [16] [17] [18] [19], whereby forms a hierarchical twin-layer network framework. Therefore, they are composed as a gainful way to balance the whole cellular system's traffic. In one side, the Femtocells that accessed by the end users can attain an enhanced signal quality, because of the minimized transmit-receive distance. Conversely, Femtocells can enhance the indoor coverage from the point of operators, whereby the great quantity of indoor traffic is conveyed. Femtocell networks [12] [13] [25] normally not capable of employing dedicated backhauls for signalling exchange, contrast to Macrocells.

The interference in the Femtocell network may be caused while using the femtocells in poor or no coverage areas, macro/femto interference is suspected as a problem. Further, the interference can occur, when the femtocell network has shared the channel (co-channel) with the macro network. Another issue that creates the interference [20] to macro network is on while deploying the femtocell network over the adjacent dedicated channel. Closed access denotes the worst-case scenario for interference creation, whereas open access might reduce the User Equipment chance (3G data dongles, mobile phone handsets and so on) on the interference of macro network with an adjacent femtocell. These all issues can be solved by adopting the interference management [14] [15] techniques insisted by Femto Forum in many cases.

Because of the Femtocell base stations (FBSs) are put separately by users and their employment has not known by macrocell base stations (MBS). Though, the system capacity is restricted by the introduction of interference by means of co-channel femtocells. Further, the network performance has been reduced by the inter-tier and cross-tier interference. Therefore, in the literature, various intercell interference avoidance/mitigation [21] [22] methods have been evolved. Even though, when multiple femtocells is coordinated, there exist the transmission delay, whereby provides the femtocell networks with promising centralized algorithm. Therefore, the developing of distributed resource allocation method is essential for enhancing the data rates and for mitigating the interference crosswise OFDMA-based femtocell networks [23]. Till now, in Femtocell networks, many of the earlier research learning has concerned over the single optimization issues such as increasing of utility of throughput, when assured other parameters as constraints.

The main contribution of this research is as follows.

1. This research introduces a macrocell and femtocell networks, which is accomplished through resource allocation and power control model.
2. These resource allocation and power control processes occupies the prime role in macrocell-femtocell HetNets.
3. As a novelty, the multi-objective resource allocation (price, power, and subcarrier) are considered as single objective and accomplished through the efficiency of optimization algorithms.
4. For this purpose, the resource allocation and power control is optimally performed using a LA model.

II. Literature Review

A. *Review*

Table I prefers the features and challenges of the conventional models regarding the optimization-based resource allocation in Macrocell-Femtocells network. Some of the few methods are explained in this with their pros and cons. Distributed power control scheme [1] has enhanced network performance, reduced signaling overhead, less computation and attain higher spectrum efficiency. The main challenge possessed by this method is only the co-tier interference has considered and has low convergence and power utilization ratio. FFR [2] has improved macrocell throughput and performance. However, reduces the network capacity. WBPPM [3] has maximum efficiency and superior convergence. But, both the bandwidth and power is applied with same weight. Multi-objective optimization technique [4] poses reduced total transmission power and the energy efficiency is better. Still needs further approaches for handling the issues on wireless communication systems. Greedy algorithm [5] has better solution to network connectivity problems and convergence outcome. The interference among User Equipment's in diverse UE modes needs to be considered and mobility analysis performance is needed, which are the two issues related to this methodology. Two-tier network model [6] has highest achievable throughput. But, needs understanding between the energy-efficient trade-off and spatial reuse and further improvement needs in network capacity, coverage and reliability. Robust optimization model [7] poses effective limitation in resources and has better computation of power. However, minimizes the adaption to variable environment. Triple optimization strategy [8] has attained faster convergence and accomplish better utility maximization. Thus, needs investigation on the effect of user mobility on the performance of FD heterogeneousnetwork.

TABLE I. FEATURES AND CHALLENGES OF CONVENTIONAL MODELS IN TERMS OF OPTIMIZATION-BASED RESOURCE ALLOCATION IN MACROCELL-FEMTOCELLS NETWORKS

Author [citation]	**Methodology**	**Features**	**Challenges**
Zheng *et al.* [1]	Distributed power control scheme	• Enhanced network performance • reduced signaling overhead • Less computation and attain higher spectrum efficiency	• Only the co-tier interference has considered • Low convergence and power utilization ratio
Jin *et al.* [2]	FFR	• Improved macrocell throughput • Better macrocell performance	• Reduces the network capacity
Li and Wang [3]	WBPPM	• Maximum efficiency • Superior convergence	• Both the bandwidth and power is applied with same weight
Mili *et al.* [4]	Multi-objective optimization technique	• Reduced total transmission power • Energy efficiency is better	• Needs further approaches for handling the issues on wireless communication systems
Li *et al.* [5]	Greedy algorithm	• Better solution to network connectivity problems • Better convergence outcome	• The interference among User Equipment's in diverse UE modes needs to be considered • Mobility analysis needs to perform
Cheung *et al.* [6]	Two-tier network model	• Highest achievable throughput	• Understanding between the energy-efficient trade-off and spatial reuse is needed • Further improvement needs in network capacity, coverage, and reliability
Liu *et al.* [7]	Robust optimization model	• Effective limitation in resources • Better computation of power	• Minimizes the adaption to variable environment
Zeng *et al.* [8]	Triple optimization strategy	• Attains faster convergence • Accomplish better utility maximization	• Needs to investigate the effect of user mobility on the performance of FD heterogeneous network

Table I prefers the features and challenges of the conventional models regarding the optimization based resource allocation in Macrocell-Femtocells network. Some of the few methods are explained in this with their pros and cons. Distributed power control scheme [1] has enhanced network performance, reduced signalling overhead, less computation and attain higher spectrum efficiency. The main challenge possessed by this method is only the co-tier interference has considered, and has low convergence and power utilization ratio. FFR [2] has improved macrocell throughput and performance. However reduces the network capacity. WBPPM [3] has maximum efficiency and superior convergence. But, both the bandwidth and power is applied with same weight. Multi-objective optimization technique [4] poses reduced total transmission power and the energy efficiency is better. Still needs further approaches for handling the issues on wireless communication systems. Greedy algorithm [5] has better solution to network connectivity problems and convergence outcome. The interference among User Equipment's in diverse UE modes needs to be considered and mobility analysis performance is needed, which are the two issues related to this methodology. Two-tier network model [6] has highest achievable throughput. But, needs understanding between the energy efficient trade-off and spatial reuse and further improvement needs in network capacity, coverage and reliability. Robust optimization model [7] poses effective limitation in resources and has better computation of power. However, minimizes the adaption to variable environment. Triple optimization strategy [8] has attains faster convergence and accomplish better utility maximization.

Problem Definition

While using the femtocells in poor or no coverage areas, macro/femto interference is suspected as a problem. Further, the interference can occur, when the femtocell network has shared the channel (co-channel) with the macro network. Another issue that creates the interference [20] to macro network is on while deploying the femtocell network over the adjacent dedicated channel. One of the other issues is closed access denotes the worst-case scenario for interference creation, whereas open access might reduce the User Equipment chance (3G data dongles, mobile phone handsets and so on) on the interference of macro network with an adjacent femtocell. These all issues can be solved by adopting the interference management [14] [15] techniques insisted by Femto Forum in many cases.

The inter-cell interference [24] is a challenging problem in heterogeneous networks, as because of the Femto base stations are put separately by users and their employment has not known by macrocell base stations (MBS). Though, the system capacity is restricted by the introduction of interference by means of co-channel femtocells. Further, the network performance has been reduced by both the inter-tier and cross-tier interference. Till now, in Femto networks, many of the earlier learning has concerned over the single optimization issues such as increasing of utility of throughput, when assured other parameters as constraint.

Proposed work

Compared with macrocell-centric networks, small cells including femtocell base stations (FBSs) and picocell base stations (PBSs) can significantly increase the system capacity and enhance the coverage of networks. In the heterogeneous small cell networks, such as the macrocell-femtocell HetNets, FBSs are set up individually by users and their deployment may be unknown to the macrocell base stations (MBS), thus, the inter-cell interference defines the power allocation, subcarrier allocation and price allocation. This research further scruntize the issues on resource allocation and cross-tier interference mitigation in full-duplex (FD) Orthogonal Frequency Division Multiple Access (OFDMA) based heterogeneous networks (HetNets) consisting of macrocell and underlaying femtocells. Conventionally, in [8], these three allocation problems (Power, Subcarrier and Price) were taken as separate constraints on macrocell and femtocell networks and optimized individually by defining as triple optimization strategy. In this research, major contributions will be subjected:

(i) Introducing the concept of Lion Algorithm (LA) algorithm for solving the above mentioned optimization problem in Macrocell-Femtocell Networks. In fact, both LA [26] is the new renowned nature inspired algorithm that solves the multi-objective constrained optimization problems.

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4.2.2 Conventional LA

Traditionally, LA [26] computes using the social behavior of lions that focus on the territorial defence and territorial takeover functions for optimally solving the problems through 6 phases like (i) Pride generation, (ii) Fertility evaluation, (iii) Mating, (iv) Territorial defence, (v) Territorial takeover and (vi) Termination.

Pride Generation: Initially, the territorial lion A_{male}, lioness A_{female}, and nomadic lion A_{nomad} are initialized and is then indicated as vector elements like a^{ie}_{male}, a^{ie}_{female}, and a^{ie}_{nomad} having the max and min range for $x > 1$, in which, $ie = 1,2,\ldots,Ie$, Ie points to the lion pack's length as stated in Eq. (20). Here x and y refers to the integers to estimate the lions length.

$$Ie = \begin{cases} x; & x > 1 \\ y; & otherwise \end{cases}$$

(20)

LA vector elements exploits either 1 or 0, if $x = 1$, binary encoded lion is used to begin the search as given in Eq. (21) and (22).

$$h(a^{ie}) \in (a^{ie}_{\min}, o^{ie}_{\max})$$

(21)

$$y\%2 = 0$$

(22)

$$h(a^{ie}) = \sum_{ie=1}^{Ie} a^{ie} 2^{\left(\frac{Ie}{2} - ie\right)}$$

(23)

Fertility Evaluation: Local optimal issues are eliminated in this phase. When A_{male} laggard and its laggardness rate become D^r is increased by 1, then $f(A_{male})$ exceeds ref_{fit}, the reference fitness. If D^r values increased than the max range of $D^r_{\max}$, it enters to territorial defence. The sterility rate V^r increases by 1 that guarentees the fertility of A_{female} after every crossover. While V^r increased than the tolerance of $V^r_{\max}$, update A_{female} to $A_{female+}$ as per Eq. (24), in which, $a^j_{female+}$ and $a^{ie}_{female+}$ with j^{th} and ie^{th} vector elements of $A_{female+}$. In addition, j specifies an arbitrary integer in the range $[1, I]$, $rand_1$, and $rand_2$ refers to an arbitrary integer for the interval $[0-1]$, and ∇ represents the female update function.

$$a^{ie}_{female+} = \begin{cases} a^j_{female+}; & when\ ie = j \\ a^{ie}_{female}; & otherwise \end{cases}$$

(24)

$$a^j_{female+} = \min\left[a^j_{\max}, \max\left(a^j_{\max}, \nabla_j\right)\right]$$

(25)

$$\nabla_j = \left[a^j_{female} + (0.1rand_2 - 0.05)\left(a^j_{male} - rand_1 aj^j_{female}\right)\right]$$

(26)

Mating: In this phase, crossover and mutation are the primary process and an auxilliary process named gender clustering are performed. At the end, A_{male} and A_{female} creates 4 cubs to the maximum. Additionally for the creation of every cub, the the crossover mask cm differs and is stated as e^{th} mask cm^e is utilized to achieve $A^{cubs}(e)$. After crosser, all cubs undergo mutation that produces another 4 cubs and id represented as A_{new}. Finally, gender clustering is performed for all 8 cubs and creates A_{b-cubs} and $A_{gc-cubs}$ and are used for self-update.

LA Operators: Typically, it is organized as creating nomad coalition, survival fight, pride, and nomad coalition updates. Eq. (27)-(29) defines the nomad coalition approach is generalized through winner take-all process to find out $A_{c-noamd}$.

$$ref_{fit}(A_{c-nomad}) < ref_{fit}(A_{male}) \quad (27)$$

$$ref_{fit}(A_{c-nomad}) < ref_{fit}(A_{b-cubs}) \quad (28)$$

$$ref_{fit}(A_{c-nomad}) < ref_{fit}(A_{gc-cubs}) \quad (29)$$

If $A_{c-nomad}$ is conquered, update nomad coalition which chooses A_{nomad}, while A_{male} is conquered, update pride which chooses $A_{c-nomad}$. In territorial takeover, A_{male} and A_{female} are updated, when A_{b-cubs} and $A_{gc-cubs}$ increased than the maximum maturity age $age_{\max}$.

Termination: LA computation is ended through obtaining any 1 of the equations expressed in Eq. (30) and (31).

$$ti > ti_{\max} \quad (30)$$

$$\left| ref_{fit}(A_{male}) - ref_{fit}\left(A_{optimal}\right) \right| \le e(Th) \quad (31)$$

Herein, ti represents the number of generations, at first it is 0 and increasing by 1 after every territorial takeover, $ti_{\max}$ refers to the maximum number of generations, $e(Th)$ points to the error threshold, and $|\bullet|$ signifies the absolute difference. Furthermore, $A_{optimal}$ is exploited only when the target min or max value is known. Algorithm 2 shows the pseudo code of conventional LA model.

Algorithm 2: Conventional LA

Begin

Initialize A_{male}, A_{female}, and A^{1}_{nomad}

Compute $f(A_{male})$, $f(A_{female})$, and $f(A^{1}_{nomad})$

Set $ref_{fit} = f(A_{male})$ and $iteration = 0$

Store A_{male} and $f(A_{male})$

Compute fertility estimation

Compute mating and compute cubpool

obtain gender clustering and A_{b-cubs} and $A_{gc-cubs}$

Set $age_{cub} = 0$

Execute cub growth function

Apply defense;

if defense result is zero, then to storing phase

if $age_{cub} < age_{\max}$, go to cub growth function

Apply territorial takeover and achieve updated A_{male}, and A_{female}

Increase $iteration$ by 1

When the ending criteria is achieved finish the execution else go to storing stage

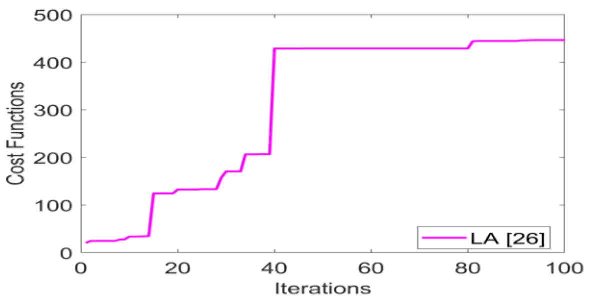
4.2 Results and Discussions

B. 4.4.1 Simulation Setup

The macrocell-femtocell network is implemented in MATLAB 2018a and the experimental investigations were carried out. The efficiency of the proposedLA algorithm for optimized macrocell-femtocell network was compared with the traditional models and obtained the results based on convergence and statistical analysis.

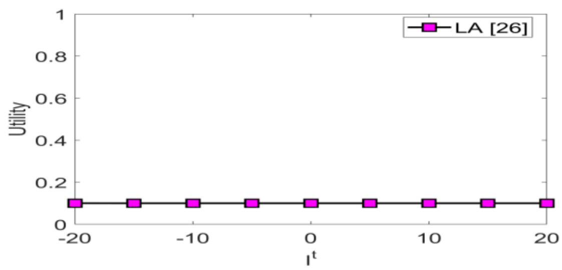
4.2.2 Convergence Analysis

In this section, the convergence analysis of the proposed macrocell-femtocell network is discussed. Fig. 4.4 shows the convergence analysis of proposed LA model



4.2.3 *Utility Analysis*

The utility analysis of macrocell-femtocell HetNets is explained in this section. Fig. 4.4 shows the utility analysis LA



Conclusion

An Optimal Resource Allocation And Power Control For Macrocell-Femtocell Network Was Proposed In This papert. . Moreover, This Scrutinized The Issues On Resource Allocation And Cross-Tier Interference Mitigation In Hetnets Including Macrocell And Underlaying Femtocells The Three Major Contributions Subjected Such As Defining A Single Objective Problem For Resource Allocation And Power Control Were Efficiently Achieved For Macrocell-Femtocell Networks,

1 CONCERNING THE COST FUNCTION, BETTER ATTAINED LA.

2 FOR UTILITY ANALYSIS, IT ACCOMPLISHED SAME IN LA

3 FOR STATISTICAL ANALYSIS, POWER FOR MACRO USER OF LA ATTAINED BETTER RESUL

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