Interference-Aware Cooperative Energy Efficiency Maximization Algorithm in 5G Ultra-Dense Networks

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Abstract: Ultra-dense networks can further improve the spectrum efficiency (SE) and the energy efficiency (EE). However, the interference avoidance and the green design are becoming more complex due to the intrinsic densification and scalability. This research analyze the relationship between the EE and the SE, based on which we formulate the Nash-product EE maximization problem. Proposed work achieves the closed-form sub-optimal SE equilibrium to maximize the EE performance with and without the minimum SE constraints. This paper propose a Cooperative Energy Efficiency Maximization Game algorithm, and numerical results verify the improved EE and fairness of the presented Cooperative Energy Efficiency Maximization Game algorithm compared with the non-cooperative scheme. In this proposed method, the spectral efficiency and Energy efficiency are improved. The numerical results are verifying using MATLAB simulations.

***IndexTerms* – Interference, Ultra-Dense, Wireless, Communication, Energy, Spectrum, Efficiency, Small Cells.**

I. INTRODUCTION

The fifth generation (5G) mobile communication systems are facing novel challenges due to promising mobile Internet and Internet of Things applications. 5G should be with both spectrum efficiency (SE) and energy efficiency (EE). Increasing network densification is regarded as one of the powerful ways to jointly enhance them in a cost-effective manner. However, ultra-dense deployment of small cells also introduces novel technical challenges, e.g., the interference. In order to avoid the interference and increase the SE, some useful observations of interference management were reported in, e.g., the more irregular and denser deployment of small cells, the higher gains in interference mitigation. However, the interference and green design problems in the ultra-dense networks are becoming more complex due to the intrinsic densification and scalability. On one hand, ultra-dense small cells underlay the macro cell, which introduces complex interference. It is hard to analyze the interactive behaviors and strategic decision-making among different small cell eNBs (SeNBs).

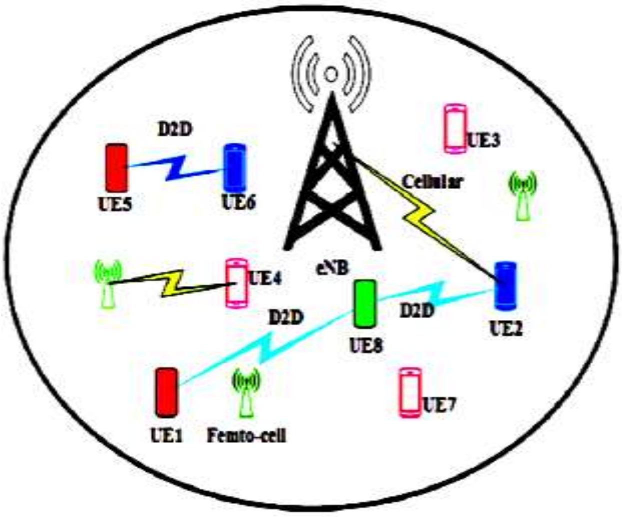

Figure 1: 5G Ultra dense network

Meanwhile, the scalability is also challenging in specific hotspots. On the other hand, distributed resource management and interference control will be more effective in ultra-dense networks. However, the signaling overhead will always be high, which challenges and burdens the backhaul of the networks. Different from the existing research on interference mitigation by improving the SE performance only, in this work, we study the EE maximization problem by exploring and exploiting various cooperative diversity gains. First, it is known that the denser the small cells are, the more cooperative diversity gains can be explored to mitigate interference, thus improving the SE and the EE performance. Second, to explore the intrinsic characteristics of ultra-dense networks, game theory can well characterize the interactive behaviors and strategic decision-making among different small cell players.

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II. BACKGROUND

M. J. Daas et al., propose a novel agreeable energy the executive’s structure for 5G UDN utilizing diagram hypothesis. The 5G network is first demonstrated as a chart; at that point diagram hypothesis strategies are abused to decide the request for hubs at which power-off/on methodology is applie [1]. F. Malandrino et al., presents testing of different plan with both a genuine world testbed based on OpenStack and OpenDaylight, and an enormous scope copied network whose geography and traffic originate from a certifiable versatile administrator, discovering it to reliably beat cutting edge choices and intently coordinate the ideal [2].

F. Elsherif et al., presents the plan with the basic instance of one-client one-ON. We then continuously and deliberately stretch out this plan to the multi-client multi-ON situation. Reproduction results show the capability of our novel methodology of abusing client portability data inside the MDP system to accomplish noteworthy energy reserve funds while giving nature of-administration ensures [3]. J. Posse et al., presents the two assets and power joint allocation calculations are intended to take care of the advancement issue in polynomial time. Based on 3GPP network definition, a thorough examination by means of a wide arrangement of mathematical examinations uncovers those huge additions in network scenario [4].

J. Chakareski et al.,presents the inward layer figures a streamlining issue to boost the framework energy efficiency (EE), defined as the proportion between the total client information rate conveyed by the framework and its total energy utilization (downlink transmission and circuit power) [5]. A. A. Salem et al., present the contrasted against single target plot with show the noteworthiness of the plan tradeoff. Besides, we will present a definite numerical investigation for UL power strategy and channel assessment for solid pilot reusing. Recreation results will show that our proposed arrangement ensure wonderful EE execution through diminishing the quantity of sent BSs without sacrificing administration quality [6].

C. Weng et al., the sensible radio spread; we model the channel quality by bend fitting and make a Markov chain based channel model. The reference signal for divert estimation in customary cell frameworks can be sent to the entire cell at once, yet the bar clearing is required in mmWave frameworks so as to conquer the high way loss of high-recurrence electromagnetic wave [7].

Z. Tune et al., presents the mixture MC-NOMA mode altogether outflanks MC-NOMA and OMA regarding SE-EE tradeoff, and the presentation gain brought by at least four clients having the equivalent subcarrier is negligible. the cross breed MC-NOMA additionally shows incredible potential to improve the tradeoff among decency and framework efficiency [8]. A. Deshpande et al., stage hereditary calculation is utilized to decrease number of highlights and further staggered gathering classifier is utilized for arrangement of information into various assault gatherings. From result examination it is dissected that with diminished element interruption can be arranged all the more productively [9]. J. Tang et al., presents sub gradient looking through plan is then proposed for the external layer so as to acquire the ideal helper factors. Mathematical outcomes affirm the adequacy of the proposed calculations and show that noteworthy presentation gain regarding EE can be accomplished by receiving the proposed broadened BC-Macintosh duality-based calculation [10].

O. Aydin et al., presents the mathematical outcomes delineate the impact of the administrator explicit SLA prerequisites on the worldwide ghostly and EE. Three network situations are considered in the mathematical outcomes, every one comparing to an alternate SLA, with various administrator explicit EE and SE requirements [11]. A. Yadav et al., presents the reenactments look at the network situation which represents uplink channel rate-subordinate energy utilization with that which disregards it. Results advocate the requirement for upgrading of the asset allocation plot [12].

III. METHODOLOGY

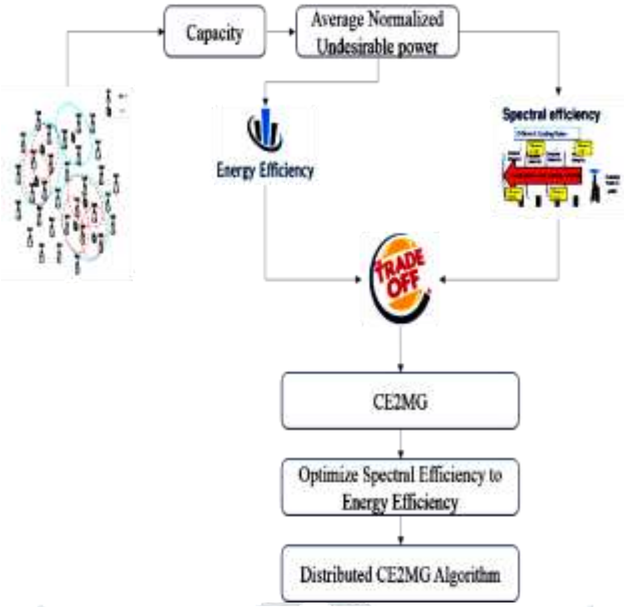

Figure 2: Flow diagram

Cooperative Energy Efficiency Maximization Game (CE2MG)

Implement the mean field approach to characterize and mitigate the complex interference influence. This approach can be applied in the ultra-dense networks with easier analysis of the relationship between the EE and the SE. With the known interference scenario, we provide closed-form relationships between the SE and the EE in different cases.

Advantages:

- Improving the Energy Efficiency.
- Performance of Spectral Efficiency will be improved
- Reduced Interference.

Formulate a cooperative energy efficient maximization game (CE2MG) model and propose a distributed CE2MG algorithm to achieve the optimal SE solution of each player maximizing system EE. Bargaining-based cooperative game can guarantee the performance of both the efficiency and the fairness among different SeNBs.

It is known that the optimal Nash cooperative bargaining solution (NBS)-based control will achieve an optimal tradeoff between Nash fairness and Nash axiomatic efficiency under the framework of Nash axiomatic theory, which has been verified in our previous NBS-formulated work. In summary, the cooperative EE maximization game can be achieved by solving the Nash-product problem where ´ min 1 and ´ min 2 are regarded as the disagreement points. Generally min 1 and´ min 2 are set as the minimal energy efficiency requirements of the participating players. With these basic statements of Nash bargaining game of a two-player case, we define the L-player cooperative EE maximization game as follows.

The player's EE preference regarding the tradeoff between EE and SE as described. The optimal total utility in the Nash-product form defined in the presented (CE2MG) framework guarantees both the efficiency and the fairness, which has been proved. In the following, we first define the cooperative bargaining solution of the CE2MG and investigate its properties. We use the straightforward achieved definition in game theory to describe the equilibrium behaviors.

IV. SIMULATION RESULTS

The proposed system model implemented using the MATLAB software. The following parameters or system constraint are taken to design the UDN model. We set the system parameters as the bandwidth W = 20MHz, background noise power is 2e¡13 Watt with the noise power spectrum density as -174dBm/Hz. The average channel gain is 2:5e¡10, which is determined with the fading model of 148+40log10[d], where d is the maximum coverage radius of various SeNBs in the unit of km. The average number of SUE m_l = 5 associated to each SeNB, the effectiveness of the power amplifier = 0:8, the minimum EE requirement = 1, and the introduced Lagrangian factors = 1.

Table 1: System parameters

Sr. No	Parameters	Value
1	Simulation area	2000 X 2000 mm^2
2	Noise Power Spectrum Density	-174
3	Spectrum Bandwidth (w)	20 MHz
4	Number of SeNBs	600
5	Macrocell eNB	5

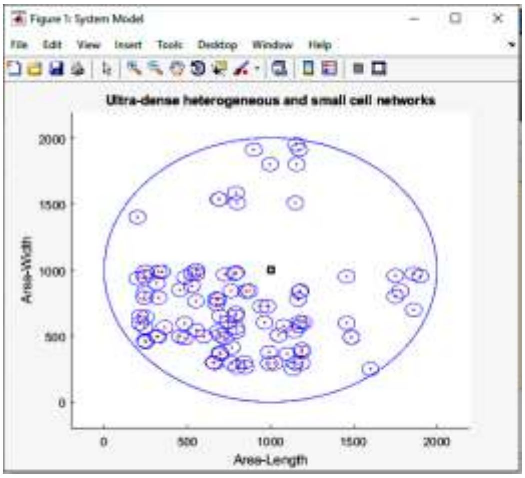

Figure 3: System model

The figure 3 is showing the system model, where 2000 X 2000 mm^2 area is taken. Interference in an UDN becomes more severe, with higher volatility, and there may be a large number of strong interferers but none dominant.

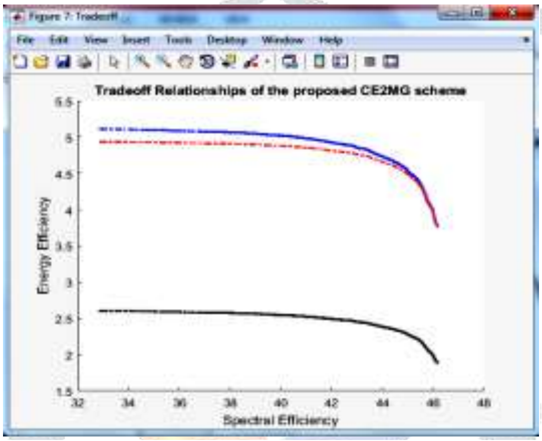

Figure 4: Tradeoff relationships of proposed CE2MG with different assumptions

Figure 4 is showing the tradeoff relationships of the proposed CE2MG scheme with different assumptions of fixed effective interference plus noise power and the normalized static power consumption.

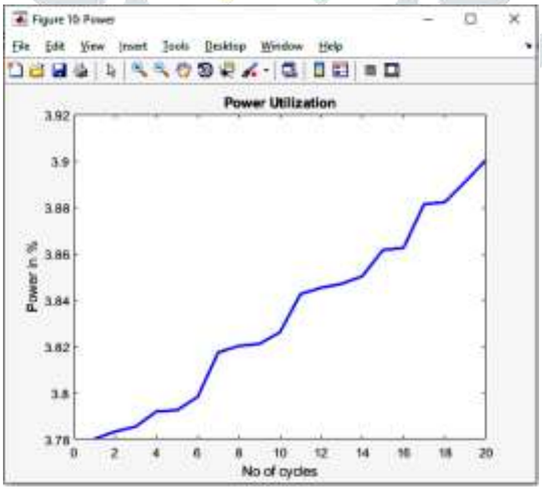

Figure 5: Power Saving

The figure 5 presents an energy management or power saving for heterogeneous UDG networks based on Cooperative EE maximization game (CE2MG). The proposed algorithm reduced power consumption. 3.92 W power is utilized so aprox 96% power is saving.

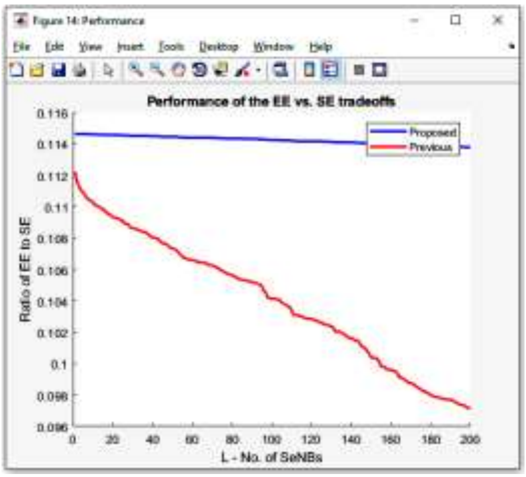

Figure 6: Comparison of Ratio of EE and SE

Figure 6 showing the Ultra-dense networks enhance the system capacity via exploring both spatial and frequency diversities.

Table 2: Comparison of existing and proposed work

Sr No.	Parameters	Existing work result	Proposed Work result
1	Method	Graph Theory	Cooperative EE maximization game (CE2MG)
2	Power Saving	60%	96%
3	Number of nodes	10000	10000
4	Simulation Time	NA	3.5 Sec
5	Number of cycle	14	20
6	Average Connectivity	0.21	0.5
7	Full load power	20 W for single and 1200 W for multiple	3.92 W to 174 W
8	Number of TRx	1 for single and 8 for multiple	1 for single and 8.7 for multiple
9	Spectral Efficiency	NA	56
10	Energy Efficiency	NA	5

V. CONCLUSION

Thus the Spectral Efficiency and Energy Efficiency were improved in this process. Compared with Cooperative Energy Efficiency Maximization Game algorithm with constraint and without constraint the Energy Efficiency will be increased. The interference will be avoidance. Ultra-dense networks enhance the system capacity via exploring both spatial and frequency diversities. The interference and green design problems were more complex due to the intrinsic densification and scalability, and at the same time it requires distributed control with reduced signaling overhead.

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