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OPTIMAL PLACEMENT OF PICOCELLS TO ENHANCE THE PERFORMANCE OF ENERGY AWARE TRAFFIC OFFLOADING FOR GREEN HETEROGENEOUS NETWORKS

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Abstract: Traditional macro-cell networks are experienced an increase of data traffic and small-cells are deployed help to offload the traffic from macro-cells. The Energy Aware Traffic Offloading for Green Heterogeneous Networks (EATOG) approach is analyzed on grid power saving by offloading traffic for green heterogeneous networks to increase the efficient utilization of harvested energy for on-grid power saving while satisfying the Quality of Service (QoS) requirement. The EATOG is mainly intends to of energy-aware traffic offloading for HCN with multiple Small cell Base Station (SBS) powered by diverse energy sources which reduces the on-grid network power consumption while satisfying the QoS requirement in terms of rate outage probability. The performance of energy consumption is degraded due to the Overlapped Small Cell Based Stations. An optimal deploying low power node within macrocell coverage area is proposed in this paper to improve the system utility while minimizing the installation cost. The proposed Optimized Energy Aware Traffic Offloading for Green Heterogeneous Networks (OEATOG) approach is considers the inter-cell interference and the configuration of Almost Blank Sub-frames (ABS) when maximizing the system utility. The proposed paper deals with the placement of Pico Base Station within the macro cell in LTE (Long Term Evolution) heterogeneous networks. A Pico Cell is a small cellular Base Station (BS) which supports low power nodes and offers greater capacity and coverage areas. Furthermore the heuristic algorithm is introduced too efficiently solve the formulated problem and obtain the optimal picocell placement. The simulation results indicate that the proposed algorithm is to improve the utility of the network, especially in regions with high traffic density, while maintaining the installation cost at a reasonable level.

Keywords: Traffic offloading, Heterogeneous Networks, inter-cell interference, LTE, BS, On-grid power.

I. INTRODUCTION

Recent days [1], the use of mobile data is increased exponentially and the Average Revenue per User (ARPU) is not increased accordingly. To improve the operator costs are best ways to increase this situation. Consider the heterogeneous networks, the data rate and capacity is increased in small cells even the large macro cells and which are assured extensive coverage. The figure 1 represents the architecture of Heterogeneous Networks.

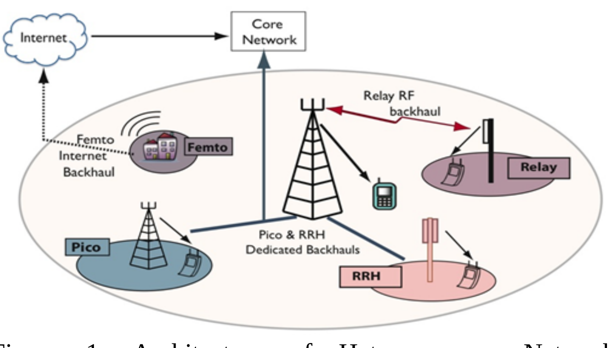

Figure 1. Architecture of Heterogeneous Networks

The another way for achieving the cost effective mobile connectivity would be to upgrade existing radio access technologies to support higher data rates. This is involved to redeploy the spectrum to reach improved spectrum efficiency with the same Remote Radio Head (RRH) and cell site infrastructure. The deployment of Long Term Evolution-Advanced (LTE/LTE-A) [2] with its simpler network architecture and greater spectrum efficiency will associated with the operators who are attempting to keep pace with subscriber demand. These changes would require infrastructure hardware that can support multiple 2G/3G/4G radio access standards. In turn, this would ease the migration from one generation of technology to the next.

The main aspect in this paper is to investigate and design energy efficient Green HetNets that consist of a joint deployment of macro BSs and different kinds of small BSs. This research encloses the different performance aspects of HetNets such as network coverage and rate, energy consumption, network deployment strategies, mechanisms of interference management, etc.

II. LITERATURE SURVEY

Zhang, S., et.al. [3] Presented a new novel method for consuming the energy of traffic offloading to increase the efficient utilization of harvested energy for on grid power saving while satisfying the quality of service environment. Depends on the information on energy arrival and traffic load, the ON-OFF stats of SBSs and power control can be minimized. Generally, in the SBS case the power consumption is improved through activating the SBS based on which the SBS condition and optimal traffic off loading cost were founded. Furthermore, the new methodology was presented for supporting multiple small cell base stations (SBSs case) was involved operating characteristics of SBSs with difference power resources.

Antepli, M. A., et.al. [4] Presented the offline transmission completion time minimization to overcome the problem with an energy harvesting broadcast link. To achieve the optimal solutions the energy harvests may not necessarily exhaust the end of each time which could be differing later. The optimal scheduler ends the transmission to both users at the same time, exploiting the special structure in the problem, the iterative offline algorithm, Flow Right, from earlier literature, is adapted and proved to solve this problem. The solution has polynomial complexity in the number of harvests used, and is observed to converge quickly on numerical examples.

Davaslioglu, K., & Ayanoglu, E. [5] presented the sources of the inefficiencies in the networks. This research was analyzed about carbon footprint such network to generate also how much mobile traffic is needed to improve so that the carbon footprint increases tremendously, after that discusses the sources of inefficiency and potential sources of improvement in the physical layer. Additionally, considering the more energy efficiency in cellular networks in the base stations and analyzes the multitier networks to point the potential of exploiting mobility patterns to utilize the base stations energy. Finally, analyze the potential methods to minimize the inefficiency, quantify the specified importance and conclude that the improvement of energy consumption in cellular networks by ordering of magnitudes.

Zheng, J.,et.al [6] presented the green energy optimization in an Energy Harvesting Wireless Sensor Networks (EH-WSN) which have two sub problems: The dynamic mode adoption issue in temporal adaptation and energy balancing issue in spatial dimensions. The game theoretic approach is presented with reinforcement learning techniques to solve the complex coupling of the two dimensional optimization in the EH-WSN. The result shows that the proposed approach is better performed than the traditional approaches.

Dhillon, H. S., et.al. [7] Presented the new comprehensive framework to analyze the HetNets, where the each Base Stations (BS) is powered solely by energy harvesting module. Develop the novel tools with foundations in random walk theory; the fixed point analysis and stochastic geometry quantify the uncertainty in BS availability due to its finite battery capacity and inherent randomness in energy harvesting. Furthermore classify the available regions for the set of uncoordinated BS operational strategies.

Mahapatra, R.,et.al. [8] Presented the New framework for green communications in wireless HetNets. This framework is cognitive in a holistic sense and aims at improving energy efficiency of the whole system, not just one isolated part of the network. In particular, propose a cyclic approach, named as energy-cognitive cycle, which extends the classic cognitive cycle and enables dynamic selection of different available strategies for reducing the energy consumption in the network while satisfying the quality of service constraints.

Xie, R.,et.al. [9] Presented energy efficiency aspect of spectrum sharing and power allocation in heterogeneous cognitive radio networks with femtocells. In order to exploit the cognitive capability, the proposed scheme is considered a wireless network architecture in which both the macrocell and the femtocell has the cognitive capability. Then formulate the energy efficient resource allocation problem in heterogeneous cognitive radio networks with femtocells as a Stackelberg game. Furthermore the gradient based iteration algorithm is presented to find the Stackelberg equilibrium solution to solve the energy efficient resource allocation problem. The experimental result shows the proposed iteration algorithm is significantly improved in terms of energy efficiency.

Al-Zahrani, A. Y., & Yu, F. R. [10] presented two level dynamic schemes to solve the energy efficient resource allocation and inter cell interference management issues in the heterogeneous networks. In this scheme, initially assign the macro cell users with the optimum number of sub channels to achieve an operator's satisfied, balance between macro users satisfaction and improve the network efficiency. After that the remaining sub channels are left to be shared by the number of small cells. Finally, transmit power adoption method by using non cooperative game theoretic approach to reduce the co channel interference in the network. The problem occurs due to allow multiple neighboring small cells to share each sub channel. Then fully characterize the pricing factor in the penalty part of the utility function. The Nash equilibrium is analyzed and assured. Then the distributed iterative algorithm based on the fixed point theorem is presented to achieve the equilibrium of the game. Simulation result shows that the present scheme is achieved the effectiveness in various network topologies.

III. PROPOSED METHODOLOGY

The proposed system presents a new algorithm for optimal deploying low power nodes within macrocell coverage areas in green heterogeneous networks for increasing the system utility while minimizing the installation cost. Among the low power nodes, picocells are included in this paper to extend the coverage in indoor areas where outdoor signals to add network capacity in very dense traffic areas.

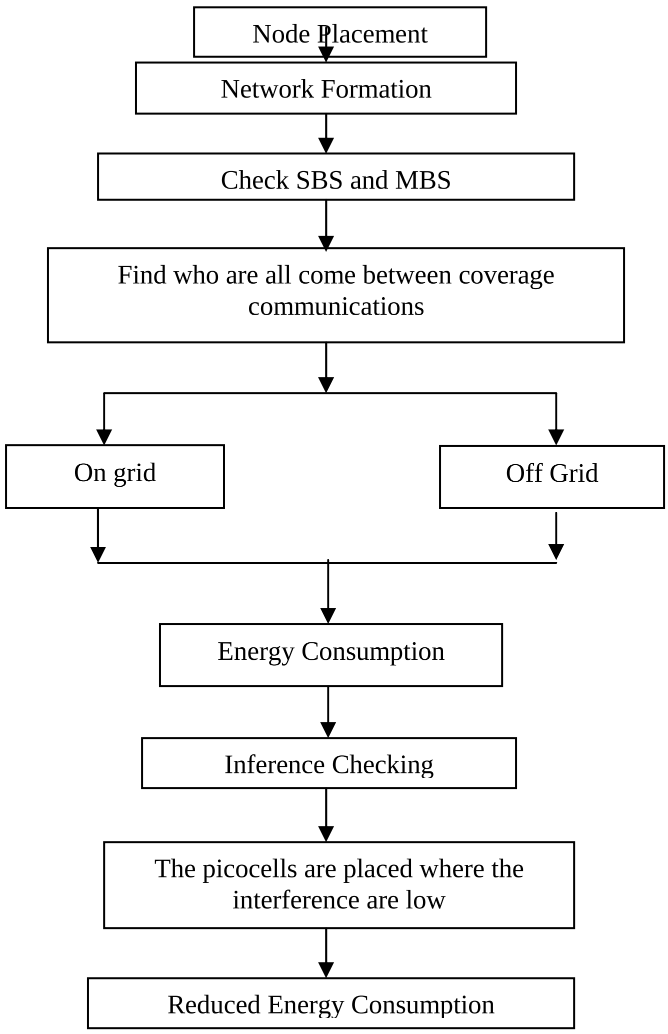

Figure 2. Proposed Framework Architecture

To maximizing the system utility, the proposed algorithm is considered inter cell interference and configuration of Almost

Blank Sub-frames (ABS). Initially, the proposed system is dealt with the placement of pico BSs within the macrocell in green heterogeneous networks. To reduce the exponential growth of computation time with respect to the number of BSs, in this paper a heuristic algorithm to efficiently solve the formulated problem and determines the optimal picocell placement.

A. *Heterogeneous Cellular Network (HCN) with diverse energy sources*

The Energy Harvesting (EH) technology is performed the distinctive situation of the HCN which is shown in figure 2. The more number of Small Cell Base Stations (SBSs) are additionally performed to further improve the network space. The SBSs are categorized in the following ways based on the energy sources,

(1) The on-grid energy is consumed the power of conventional SBSs.
(2) Harvested renewable energy is consumed the power of Renewable energy SBS.
(3) By using the energy harvesting devices and power grid powered the Hybrid SBSs.

These are described as N_C, N_R and N_H the more number of CSBSs, RSBSs and HSBSs respectively. Then, consider B=B_C, B_R, B_H be the set of SBSs. The SBS_n serves a circular area with radius $D_{s,n}$ and the small cells are considered having no overlaps with each other. The Mobile Base Station (MBS) is provides the standard coverage besides SBSs can be dynamically assured for traffic offloading or deactivated for saving the energy based on the traffic and energy status. Consider as Example, in the figure 3.1 the less loaded CSBS-1 is terminated for minimizing the power saving while the RSBS-1 is closed because requirement of more harvested energy.

B. *Cell Through put*

The In this section, when placing the kth pico BS in the area of in the pico BS placement process, then note that the interference may occur because of the new pico BS, $P_{l,k}$ the already placed pico BSs, $p_{l,1}, p_{l,2}, \ldots\ldots, p_{l,k-1}$ the macro BS, b_1 the six macro cells adjustment to $b_1, b_l (1 \leq l \leq 6)$, and the pico cells deployed within each adjustment macro cell $b_1, \{p_k^l\}$..

Initially, consider the interference from the pico BS, $p_{l,k}$ and the macro BS, b_1. Let $Pr_1(f_1)$ be the probability that the user equipment (UE) at (x, y) in the coverage area of macro BS, b_1 is placed RBs from the frequency b and f1 for both transmission direction. This probability is represented in the particular location in the following ways (x, y) and A (Area) as follows. For (x, y) $\in A_l^{(e)} - U_{k=1}^{K_l} A_{l,k'}$

$$Pr_1(f_1) = \begin{cases} 1 \ if \ |RB|_t \leq \frac{|RB|}{3} \\ 0 \ if \ |RB|_t > \frac{|RB|}{3} \quad and \ |RB|_l^{(e)} \geq \frac{|RB|}{3} \\ \frac{\frac{1}{3}|RB| - |RB|_l^{(e)}}{|RB|_l^{(c)}} \ if \ |RB|_t > \frac{|RB|}{3} \ and \ |RB|_l^{(e)} < \frac{|RB|}{3} \end{cases}$$

Where $|RB|_t = |RB|_l^{(e)} + |RB|_l^{(c)}$

Using $\Pr_1(f_1)$ the describe the probability of allocating the RBs from the frequency band f_i (i=2, 3) to the UE at (x, y) in b_1 as

$$\Pr_1(f_j) = \frac{1 - \Pr_1(f_1)}{2}, \ for j = 2,3$$

For (x, y) $\varepsilon A_{I,K}$ under the assumption of the uniform allocation of RBs within the picocell, then $\Pr_1(f_1)$ =1/3 for j=1, 2, 3.

Suppose the UE is at the location (x,y) of the specified area of the macro BS, (i.e, b_1 *is the UE' serving cell*), then represent with $P_D(x,y)$ the downlink interference from the pico and/or macro cells to the UE and with $P_U(x_1,y_1)$ the uplink interference from the UE and the pico cells to the macro BS, and $P_U(x_k,y_k)$, the uplink interference from the UE and the macrocell to the pico BS. The downlink interferences and uplink interferences from the UE to the BS, b_1 and to the pico BS, $p_{l,k}$. Defined as

$$P_1(x,y) = \sum_{i=1}^{3} Pr_1(f_i)$$

$$\begin{cases} Pr_D^{(i)}(f_i) F_1(x,y) + Pr_U^{(i)}[f_i] F_1^{UE}(x,y) \\ + \sum_{j=1,k\neq j}^{K_1} \left(Pr_D^{(i)}(f_i) F_{1,j}(x,y) + Pr_U^{(i)}(f_i) F_{1,j}^{UE}(x,y) \right), if \ UE \ is \ in \ A_{1,k} \\ \sum_{k=1}^{K_1} \left(Pr_D^{(i)}(f_i) F_{1,k}(x,y) + Pr_U^{(i)}(f_i) F_{1,k}^{UE}(x,y) \right), \ otherwise \end{cases}$$

Based on the equation, the picocells are does not overlapped with one parameter in the problem formulation but inter-pico cell interference may still occur. Then, considering the neighboring macro cells b_l and the pico cells, p_k^l within the macro cells b_l where $1 \leq l \leq 6$, then express the expected interference power at the location, (x, y) in the coverage area of macro BS b_l as

$$P_l^l(x,y) = \sum_{i=1}^{3} Pr_1(f_i) \left\{ (1-\tau) \left(Pr_D^{(i)}(f_i) F_l(x,y) + Pr_U^{(i)}(f_i) F_l^{UE}(x,y) \right) + \sum_{k=1}^{K_l} \left(Pr_D^{(i)}(f_i) F_{l,k}(x,y) + Pr_U^{(i)}(f_i) F_{l,k}^{UE}(x,y) \right) \right\}$$

Using the above equations at the location (x,y) within the coverage area of the macro BS, b_1 then the downlink SINR to the UE as follows

$$SINR_D(x,y) = \frac{P_{sig}}{\sum_{l=1}^{6} P_D^l(x,y) + P_0 + P_D(x,y)}$$

Where P_{sig} the received signal is power and P_0 is represented the noise power. Likewise, can find by $SINR_U(x,y)$ substituting $P_D(x,y)$ with $P_U(x_1,y_1)$ or $P_u(x_k,y_k)$.

Then, included the $SINR_{min}$ *and* $SINR_{max}$ be the minimum and the maximum SINRs for which the code set works. Also, let S_{max} be the maximum throughput of the code set. Then, the throughput of the code set. The throughput per RB at the location (x, y) can be derived by using Shannon's formulae.

$$S_l(x,y) = \begin{cases} 0 \ if \ SINR_l(x,y) < SINR_{min} \\ \propto \log_2(1 + SINR_l(x,y)) c, \ if \ SINR_{max} < SINR_l(x,y) \leq SINR_{min} \\ S_{max} \quad otherwise \end{cases}$$

For l= {D, U}, where $\propto$ is the attenuation factor indicating implementing losses and c=180 kHz is the bandwidth of a single RB. Since, there is no data transmitted while ABSs in the macrocell, then express the maximum throughput that can be provided in the macrocell b_1 as

$$S_1 - (1-\tau)(S_D^{(I)} + S_U^{(I)})$$

Where

$$S_i^{(I)} = \frac{1}{|A_i| - U_{k=1}^{K_i}|A_{i,k}|} \iint_{A_{i-U_{k=1}^{K_i}A_{i,k}}} \min\left(\frac{|RB|_i^{(I)}}{|RB|_i^{(I)}} \overline{|RB|}_i(x,y)\ \Pr(I) S_i(x,y), \varrho(x,y) \varrho_1(x,y)\right) dxdy$$

Let τ represents the portion of the throughput for the ABS among the total throughput. The maximum throughput in the picocell of $P_{I,k}$ is defined as

$$S_{I,k} = (1-\tau)\left(S_D^{(I)} + S_U^{(I)}\right) + \tau\left(S_D^{(I,k)} + S_U^{(I,k)}\right),$$

Where

$$S_I^{(I,k)} = \int\int_{A_{I,k}} \min\left(\frac{|RB|^{(Ik)}}{|RB|^{(Ik)}} \overline{|RB|}_1(x,y) \Pr(c,I) S_1(x,y), \varrho(x,y) \varrho_1(x,y)\right) \frac{dxdy}{|A_{I,k}|}$$

And assuming that no interference occurs during the ABSs, the $S_D^{(I,k)}$ *and* $S_U^{(I,k)}$ are obtained by applying

$$P_i(x,y) = \sum_{j=1,k\neq j}^{K_I}\left(Pr_D^{(j)}(f_i) F_{i,j}(x,y) + Pr_U^{(j)}(f_i) F_{i,j}^{ue}(x,y)\right).$$

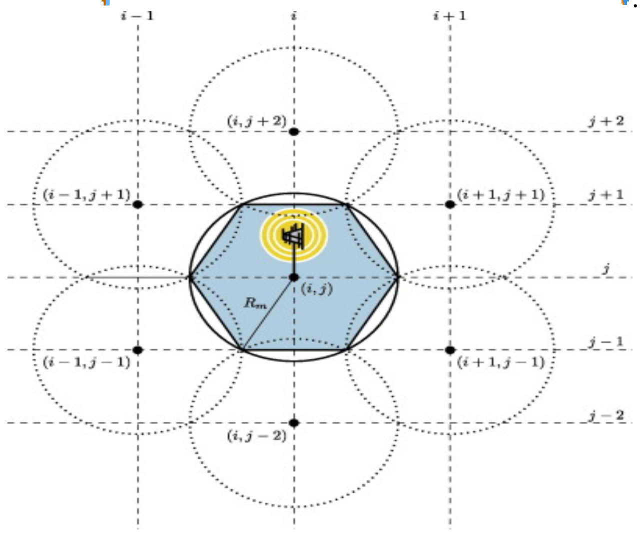

Figure 3 Placement of Macro BSs in 2D space

Figure 3 shows the pico BS placement within the macrocell coverage areas in two dimensional Euclidean spaces. This is offered the optimal placement and number of pico BSs within the macrocell coverage space, so the total throughput is improved in the heterogeneous network and reduced the installation cost.

C. Heuristic picocell placement algorithm

The proposed Heuristic algorithm handles the optimization issue. The its performed in the following ways. Initially F_n^I is represented the utility minus of the cost when added new pico BS, offered the n pico BSs are already included in the coverage area of b_1.

F_n^I=U (b_1)-$\sigma C(b_1)$

In order to find the location the utility minus is increased the cost while adding additional pico BS, then define ΔF_n^I as F_{n+1}^I-F_n^I. After that, determine the location using this present algorithm. Then describe the ΔF_1^I in the same manner as ΔF_0^I to find the location for second pico BS, $p_{I,2}$ within the $A_{I,p}$ where ΔF_1^I is maximized. Since, a selection of candidate is improved ΔF_1^I within $A_{I,p}$not choose the $p_{I,2}$ if it would output in d($p_{I,2}, p_{I,1}$)<2R_p. Repeat this process with ΔF_n^I and $A_{I,p}$ till the constraints are satisfied. Similarly, the for $Opt_I$is provided when replacing the condition of the while loop with $\frac{\left(S_I + \sum_{k=1}^{K_I} S_{I,k}\right)}{\Gamma_i < \sigma \text{ or } \exists(x,y)}$ within $A_{I,p}$ state that ΔF_n^I >0 for $\forall b_1 \varepsilon B$.

Let $|A_{i,p}|$ be the countable number of candidate points at which a pico BS can be placed. Representing with N_k, the total number of pico BSs installed, the computational complexity of the proposed heuristic algorithm is $|A_{I,p}|$XN_k, whereas the exhaustive search of the candidate area take the computation complexity of $\binom{\sum_{\forall b_j \in B}|A_{I,p}|}{N_k}$.

D. Power control

The In the early researched the consumption of power is not considered in the green heterogeneous networks. In the proposed research presents the power consumption to achieve the optimal performance of green heterogeneous networks. Furthermore the transmission power of UE is revisited and including the power control. Then, referring the macro and pico BSs use the transmit power at location (x, y) as follows.

$$Pt_1(x,y) = \begin{cases} P_{max} - 3dB \text{ if } (x,y) \text{ is in } A_i^{(e)} \text{ and } f_2 \text{ or } f_3 \text{ is used} \\ P_{max} \quad \text{otherwise} \end{cases}$$

$Pt_{I,K}(x,y)$=$P_{K,max}$

Where P_{kmax} is the maximum transmitting power of the pico BS.

The UE's transmit power, $Pt_{ue}(x,y)$ is

$$Pt_{ue}(x,y) = \min(P_{max,ue}, 10\log_{10} M_{PUSCH} + P_{0\ PUSCH} + \gamma PL)$$

Where $P_{max,ue}$ is described the UE's maximum power level, M_{PUSCH} is described the bandwidth of the physical uplink shared channel (PUSCH) assignment represented in the number of RBs valid for the sub frame and the serving cell, P_{0_PUSCH} is a parameter composed of the sum of a cell specific nominal component, $P_{0\_nominal}$ and a UE specific component $P_{0,ue}, \gamma \in \{0, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1\}$ is the 3-bit cell specific parameter provided by higher layers for the serving cell and PL is the path loss in the UE for the serving cell.

Algorithm for Heuristic BS placement Algorithm

1. While $\frac{\sum_{\forall b_1 \in B}\left(s_I+\sum_{k=1}^{K_1} s_{I,k}\right)}{\sum_{\forall b_{1} \in B}(\Gamma_1)<\sigma}$ $or\ \exists(x,y) within\ A_{I,p}\ state\ that\ \Delta F_n^I > 0\ for\ \forall b_1 \in B\ do$
2. //Constraint in
3. Select a BS $b_1 \in B$ randomly.
4. //$U'(b_1)$ is the utility when the selected pico BS is removed.
5. //$U''(b_1)$ is the utility when the selected pico BS is removed.
6. If $\exists(x,y)$ within $A_{I,p}$ is not satisfied and $U'(b_I)$-$U(b_I)$ >0 or $\Delta F_n^I > 0$ and $d\left(p_{n+1}^I, P_k^{I'}\right) <$ $2R_p$ for $1 \leq k \leq K_{I'}, \forall b_I, \forall b_{I'} \in$ B then
7. Install a new pico BS,p_{n+1}^I at the location (x,y)
8. n=n+1
9. end if
10. if $\exists p_{i,k}$ within $A_{I,p}$ state that $U''(b_I)$-U(b_I)>0 $(1 \leq k \leq n)$ then
11. remove the pico $BS_{p_{1,k}}$
12. n=n-1
13. end if
14. end while

E. Performance Evaluation

This section is dealt with the performance of the proposed heuristic picocell placement algorithm through Ns2 simulations. The simulation result shows that the proposed method outperforms tradition trade off traffic offloading scheme for achieving energy savings.

IV. EXPERIMENTAL RESULTS

The performances of the Existing Energy Aware Traffic Offloading for Green Heterogeneous Networks (EATOG) and Proposed Optimized Energy Aware Traffic Offloading for Green Heterogeneous Networks (OEATOG) approaches are evaluated through Energy Consumption Rate, Throughput, Packet Delivery Ratio and Delay by using NS-2 Simulator.

A. Energy Consumption Rate

The Energy consumption rate is used to calculate the amount of energy used. Any process or system process can be evaluated and measured. For 60 nodes, energy consumption rate in EATOG is 1.71168 but the same time in OEATOGHN it is 1.24175.

In the same way other measures are calculated, given in below table

Table 1. Comparison Table

Calculation In Terms Of	**Number of Nodes**	**EATOGHN**	**OEATOGHN**
Throughput	30	524	598
Packet Delivery Ratio	30	71	88
Delay	30	26.9336	22.3649

B. Energy Efficiency

The Efficiency is referred to measure the how much work or energy is conserved in a process. The aim is reduced the amount of required energy required to provide the process.

Table II. Energy Consumption

Energy Consumption (%)	
Existing EATOG	84
Proposed OEATOG	97

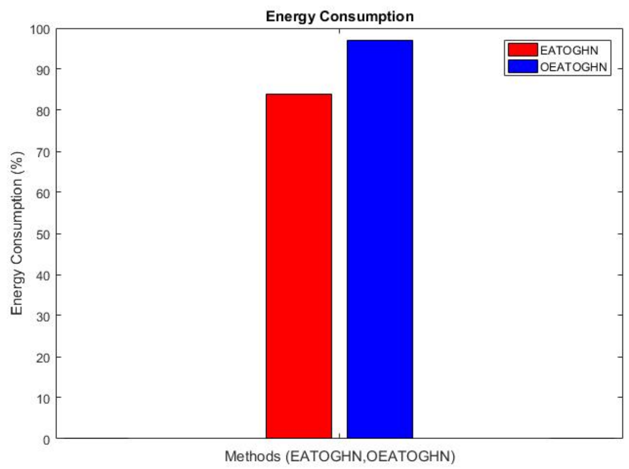

Figure 4 Comparison of Energy Consumption

Figure 4 shows that the comparisons of the proposed (OEATOG) approach with the existing (EATOG) approach in terms of energy efficiency. From the graph, it proves that the proposed OEATOG approach is consumed 13% energy than the existing EATOG approach.

V. CONCLUSION

The proposed an algorithm for optimal deploying low power nodes within macrocell coverage areas in green heterogeneous networks improves the overall throughput of the system. Then, formulated the problem of optimal picocell placement through including the inter cell interference and then configuring of ABS is represented the traffic demands in the network and the picocell installation cost. The simulation result shows the proposed picocell placement algorithm increase the utility for UEs placed in the areas of high traffic density while minimizing the installation cost of the picocell.

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