ISSN: 2278-0181
NCICCT-2015 Conference Proceedings

# Heterogeneous Cellular Networks Energy-Efficient Design Based on Large Scale user Behavior Constraints

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***Abstract*-In wireless networks, the traffic demands vary in both temporal and spatial domains. As a large amount of traffic demands may be generated in small hotspot regions, while only a small amount of traffic demands may be generated in vast non-hotspot regions. In the time dimension, a large number of users may request intensive traffic over the network in peak hours. Such user performance is referred to as the large-scale user behavior, in which they follow inhomogeneous distribution. Unsurprisingly, the large-scale user behavior creates enormous difficulties in energy efficient design of Heterogeneous Cellular Networks (HCN). Base Station (BS) density, BS broadcast power, BS static power and quality of service are consider to avoid these problems. The three energy efficient control strategies are introduced in two tier HCN deployment and configurations. These three control strategies are micro BS sleep control, coverage extension control, and coverage shrinking control. The quantitative relationship between large scale user behavior and energy efficient HCNs are present in a closed form formulas. The closed form formulas are used to compute BS density BS transmit power with the objective of achieving optimal energy efficiency. Resource allocation focusing on reducing the cross-tier interference can also lead to high energy efficiency. Simulation results validate our theoretical analysis and demonstrate that the proposed control strategies can potentially lead to significant power savings.**

***Key words: Energy-Efficient(EE), Quality of Service (QOS), Base station(BS), Heterogeneous Cellular Networks (HCNS).***

## I. INTRODUCTION

### *A.THEORETICAL ANALYSIS IN WIRELESS COMMUNICATION*

The global mobile communication industry is growing rapidly. Today there are previously more than 4 billion mobile phone subscribers worldwide more than half the entire population of the earth. Obviously, this growth is accompanied by an increased energy consumption of mobile networks. Global warming and keen concerns for the environment of the planet require a special focus on the energy efficiency of these systems.Energy-efficient green cellular networks have become a hot research topic nowadays to deal with the dramatically increasing energy consumption of cellular communications. As one of the input features of 5G networks, the energy-efficient plan is valued by operators from both the environment and economic viewpoints. For cellular networks, BSs are leading in energy consumption and consume around 60-80% of the whole network energy.The aim of this project is to seize the opportunity of tracking the traffic variation in the temporal and spatial domains of the network to adopt the radio resource allocation accordingly such that a great amount of energy can be saved. As one of the most accepted and efficient energy saving schemes, BS sleeping has a great possible in energy saving when the traffic load is low. The subsequent figure illustrates several simple BS sleeping patterns. Besides traffic active BSs, Second, traffic-aware sleeping makesequally the topology of active BSs and the interference scenarios change. So new frequency reuses pattern, development, and power control schemes should be developed accordingly aware BS sleeping, there are also new scientific problems that need to be addressed and will be studied in this project.

HCNs including usual macro BSs and distributed low power BSs are shown to have higher variety efficiency and energy efficiency. Confirmed that the deployment of low power BSs generally leads to higher EE, but this gain saturates as the density of low power BSs increases. As a result, both the performance analysis and the energy-efficient design of HCNs have become very popular recently.

The locations of BSs may have a significant impact on the outage and throughput performance of a network. However, the locations are usually unknown in the analysis and the design of the HCNs. The spatial stochastic process model is widely used to model the locations of BSs, such as the Poisson Point Process and Poisson Cluster Process.

Several important energy-efficient techniques were proposed including network planning, on-off BS operation, and cell zooming and resource allocation. Investigated the optimal combination of the density of macro BSs and micro BSs with a tradeoff between capacity extension and energy saving. For the case of low traffic demands, it was shown that turning off some underutilized BSs can improve EE significantly.

Investigated the sleeping strategy according to the temporal traffic variation and similarly proposed a cell activation mechanism that enables BSs to be activated repulsively according to traffic demands and thus the effective BS density can be scalable for traffic fluctuation.

For energy-efficient operation of low power BSs. Proposed a cell zooming mechanism where it was shown that the power consumption can be reduced by means of turning off some BSs and extending the coverage of the other BSs during periods of low traffic demands. Resource allocation focusing on reducing the cross-tier interference can also save the energy of HCNs.

## II RELATED WORKS

IN[2] X. Zhang, Y. Zhang, R. Yu, W. Wang and M. Guizani**,**In this paper gift the idea of user social pattern (USP), that characterizes the final user behavior, pattern and rules of a bunch of users as a social approach, And utilize USP as an optimization basis for network performance sweetening. From large-scale traffic traces collected from current mobile cellular networks, the USP models are evaluated and testified. Moreover to gauge the potential of spectral-efficiency (SE) and energy potency (EE) sweetening supported USP in LTE-A HetNet networks; establish a whole system and link level HetNet simulation platform consistent with 3GPP LTE-A standards. Simulation results validate that the users social pattern (USP) may be used as a good idea for network performance optimization in LTE-A system.

IN[4] Y. Huang, W. Wang, X. Zhang and J. JiangIn this paper, analyze energy conservation in multiuser networks together with multicast transmission mode supported UCB. Develop a random model and acquire the closed type formulas of the ability consumption. Propose AN energy economical traffic transmission theme supported UCB. The straight line expressions for the ability reduction magnitude relation and therefore the engineering achieved by our theme are developed, from that the impact of UCB on the energy conservation has been mentioned. Simulation results are provided to demonstrate the exceptional effects on energy conservation achieved by the projected theme. Typical study of inexperienced communication principally focuses on the transmission power adjustment to reduce the entire power consumption whereas guaranteeing a target system capability. Simulation results validate the theoretical analysis and demonstrate that theme will doubtless result in thirty fifth power consumption deduction compared with the standard transmission theme.

IN[5] Yu Huang, Wenbo Wang, Xing Zhang, Yao Wei,Propose a completely unique energy economical multicast theme. The most contribution may be summarized as follows. Firstly, think about the user behavior in media stream service by characterizing the user request frequency for various media streams mistreatment distribution. Secondly, propose a completely unique energy economical fix multicast theme with fix stream. Completely different to the normal fix multicast with mounted information measure theme, in our fix multicast theme, the transmitter will dynamically assign all idle system information measure for unicast/multicast transmission. Simulations results are provided to demonstrate the energy saving performance achieved by the projected theme beat unicast transmission and therefore the traditional fix multicast transmission.

IN[8] Xing Zhang Zhuowen Su Zhi Yan. Wenbo,This paper analyzes and compares the best energy potency of a two-tier heterogeneous network (HetNet) that consists of macro-cell and small-cells underneath coverage performance constraints for various spectrum deployments. Relationship between energy potency and density of small-cells for the 2 tier network is evaluated supported the analysis of coverage performance and so an algorithmic rule is projected to get the best density of small-cells that maximize the energy potency underneath a desired coverage demand. The results additionally show that the best density of small-cells for greatest energy potency is just captivated with the coverage performance of small-cells in orthogonal spectrum readying situation.

IN[7] Dongxu CAO, Sheng ZHOU, Zhisheng,Analyze the best baccalaureate density for each unvaried and heterogeneous cellular networks with service outage chance constraint. Supported these results, we tend to solve 2 vital issues: capability extension and energy saving, and supply a rule to work out which kind of BSs ought to be deployed or slept with higher priority. Our results reveal the simplest style of BSs to be deployed for capability extension, or to be transitioned for energy saving. Specifically, if the magnitude relation between the small baccalaureate value and therefore the macro baccalaureate value is below a threshold, that may be operate of path loss and their transmit power, the small BSs square measure most well-liked, i.e., deploy additional small BSs for capability extension or switch sure macro BSs for energy saving. Otherwise, the best alternative is that the opposite.

## III. DESCRIPTION OF THE PROPOSED SCHEME

In this project consider a general case of users in hotspot regions and non-hotspot regions are different in terms of traffic volume and the size of two regions. BS coverage can be larger or smaller than the hotspot regions or non-hotspot regions. The existing approaches cannot be applied in this case, which motivates us to design a completely new approach for modeling and analyzing HCNs based on large-scale user behavior. Specifically, our main contributions are summarized as follows:

- A tractable expression to quantitatively distinguish large-scale user behavior is presented for a scenario where heterogeneous traffic demands in hotspot regions and non-hotspot regions are taken into account.
- The quantitative relationship between large-scale user behavior and energy-efficient HCN configuration is presented in closed-form formulas. These results can be used to determine

the density and the broadcast power of BSs with the objective of achieving optimal EE.

- Three energy-efficient control strategies for large-scale user behavior are proposed, including micro BS sleep control, coverage expansion control and coverage shrinking control.
- The proposed system consists of energy geographical routing protocol used to produce the energy efficient HCN.

*A.HETEROGENEOUS CELLULAR NETWORK MODEL*

Consider two kinds of regions which are covered by a 2-tier HCN consisting of conventional macro BSs that guarantee non-hotspot region coverage and micro BSs that guarantee hotspot region traffic demands. The hotspot regions and the non-hotspot regions are differentiated by two characteristics of traffic demands. Specifically, the volume/density of traffic demands in hotspot regions is generally higher than that in non-hotspot regions. The size of hotspot regions is generally smaller than that of non-hotspot regions.
In this system, the distribution of user location and the distribution of traffic demands are considered to be different concepts. The locations of the users are in two kinds of regions are understood to follow uniform distribution with the same density but the traffic demands and size of hotspot regions and non-hotspot regions can be different.

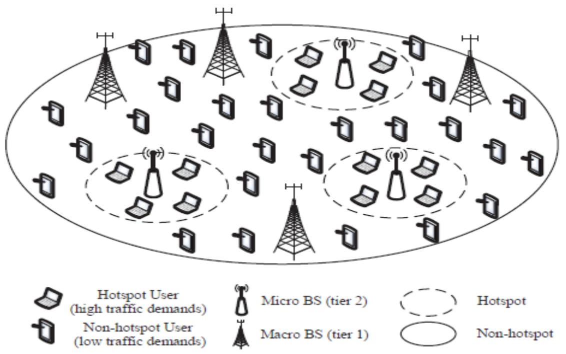


Figure1: SYSTEM MODEL

*B.CALCULATION OF SIGNAL INTERFERENCE PLUS NOICE RATIO*

$$SINR_x^k = \frac{P_k h_x \|x\|^{-\alpha}}{\sigma_n^2 + \sum_{i\in\{m,M\}} \sum_{x\in\phi_i/\{x\}} P_i h_x \|x\|^{-\alpha}} \qquad (1)$$

$$P(SINR < \beta_k) = 1 - \frac{\pi}{c(\alpha)} \frac{\lambda_k (P_k/\beta_k)^{\frac{2}{\alpha}}}{\lambda_M P_M^{\frac{2}{\alpha}} + \lambda_m P_m^{\frac{2}{\alpha}}} \qquad (2)$$

*C.POWER AND DENSITY OPTIMIZATION FOR HCNS BASED ON LARGE-SCALE USER BEHAVIOR*

In this section, introduce two optimization problemswith fixed micro BS density or fixed macro BS density. The optimal BS transmits power and the optimal BS densities based on user behavior are derived. Then we analyze the impact of the large-scale user behavior on HCN EE. Note that traffic demands in hotspot regions are completely guaranteed by micro BSs and traffic demands in non-hotspot regions are completely guaranteed by macro BSs.

$$ASR = \sum_k ASR_k = D(\alpha, \beta_{th}) \frac{\lambda_M^2 \; P_M^{\frac{2}{\alpha}} + \lambda_M^2 P_M^{\frac{2}{\alpha}}}{\lambda_M P_M^{\frac{2}{\alpha}} + \lambda_m \; P_m^{\frac{2}{\alpha}}} (3)$$

$$EE = \frac{\text{AVERAGE SPATIAL RATE}}{\text{AVERAGE SPATIALPOWERCONSUMPTION}}$$

$$EE = \frac{ASR}{\lambda_m (P_m + P_m^c) + \lambda_M (P_M + P_M^c)} (4)$$

*D .EVALUATION OF USER BEHAVIOR COEFFICIENTS*

The value of user behavior coefficient is in the interval [0; 1]. In practice, both extreme values are not usually reached. On one hand, a low user behavior coefficient indicates the large-scale user performance follows a more even allocation, with zerocorresponding to complete equality.

$$A = \frac{1}{2}\left[\frac{\gamma_m v_m}{\gamma_m v_m + 1} - \frac{\gamma_m}{\gamma_m + 1}\right] (5)$$

In the other case where $v_m$<1 the area of A can be calculated similarly. According to the definition of user behavior c3oefficient, we have

$$h = \frac{\gamma_m v_m}{\gamma_m v_m + 1} - \frac{\gamma_m}{\gamma_m + 1}, \text{if } v_m > 1 \quad (6)$$

$$h = \frac{\gamma_m}{\gamma_m + 1} - \frac{\gamma_m v_m}{\gamma_m v_m + 1}, \text{if } v_m < 1 (7)$$

## IV ENERGY EFFICIENT CONTROL STRATEGIES

In this section, we introduce two optimization problemswith fixed micro BS density or fixed macro BS density. The optimal BS transmits power and the optimal BS densities based on user behavior are derived. Then we analyze the impact of the large-scale user behavior on HCN EE. Note that traffic demands in hotspot regions are completely guaranteed by micro BSs and traffic demands in non-hotspot regions are completely guaranteed by macro BSs.

*A.COVERAGE EXPANSION AND SHRINKING CONTROL*

The traffic rate in hotspot regions is higher than that in non-hotspot regions and thus the average traffic rate in the coverage area of micro BSs will decrease when the micro BS coverage expands. Therefore, the ASR provided by micro BSs can also be reduced.The traffic rate in hotspot regions is lower than that in non-hotspot regions and thus the average traffic rate in the coverage area of micro BSs will increase when the micro BS coverage shrinks.

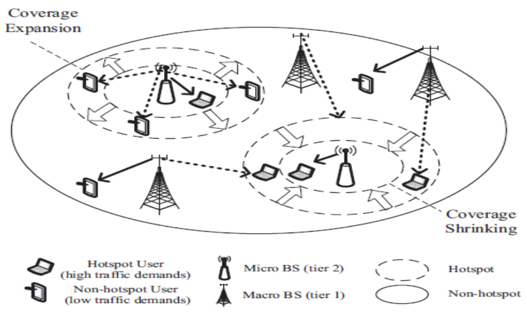


Figure 2;coverage expansion and shrinking control

*B. BASE STATION SLEEP CONTROL*

Energy-efficient green cellular networks have become a hot research topic nowadays to deal with the dramatically increasing energy consumption of cellular infrastructure. The two optimization problem with fixed micro BS density or fixed macro BS densities are the challenges in HCNs. The optimal BS transmits power and the optimal BS densities based on user behavior are derived. Then we analyze the impact of the large-scale user behavior on HCN EE. Note that traffic demands in hotspot regions are completely guaranteed by micro BSs and traffic demands in non-hotspot regions are completely guaranteed by macro BSs.

- The ASR provided by macro BSs should equal to the average traffic rate in the whole area.
- The SINR of the users in cell edge should equal to the SINR threshold.

The relationship between area ratioand EEopt implies that when power consumption per unit coverage area of micro BSs is larger than thatof macro BSs, using a micro BS to cover ahotspot will make the optimal EE decrease with traffic rate in hotspot regions. Therefore, we can turn off the micro BSsand use the macro BSs to cover all of the hotspot regions. Note that such scenario actually the homogeneous network.Besides traffic-aware BS sleeping, there are also new technical problems that need to be addressed and will be studied in this project. For example, users in sleeping cells need to be re-associated to the active BSs. Second, traffic-aware sleeping makes both the topology of active BSs and the interference scenarios change. So new frequencyreuse pattern scheduling and power control schemes should be developed accordingly.

V.RESULTS AND DESCRIPTION

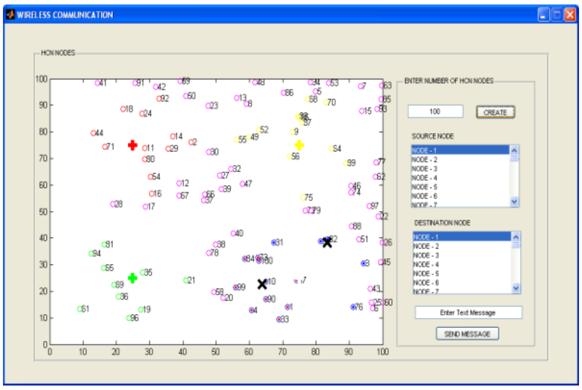


Figure 3:Graphical representation of HCN

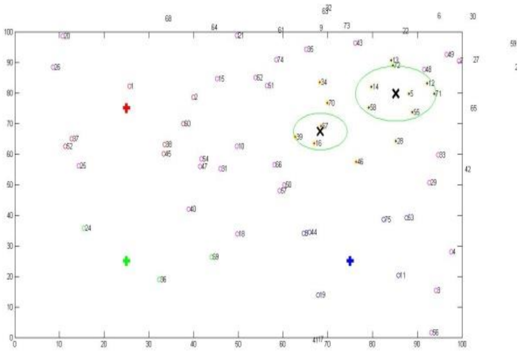

Figure 4:Coverage expansion and shrinking control

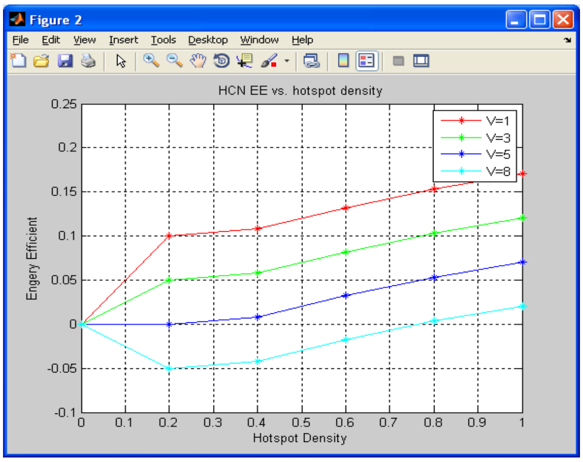


Figure 5:HCN Energy efficiency vs hotspot density

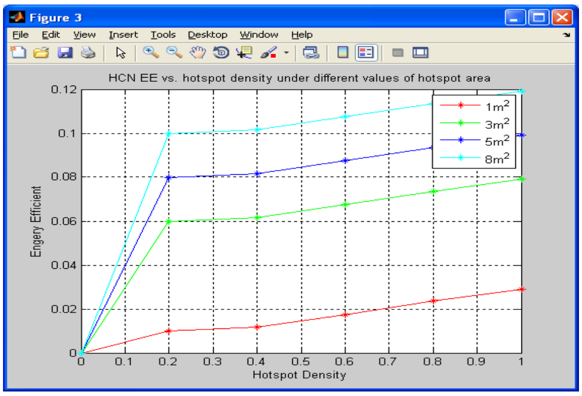


Figure 6:Energy efficiency with different hotspot densities

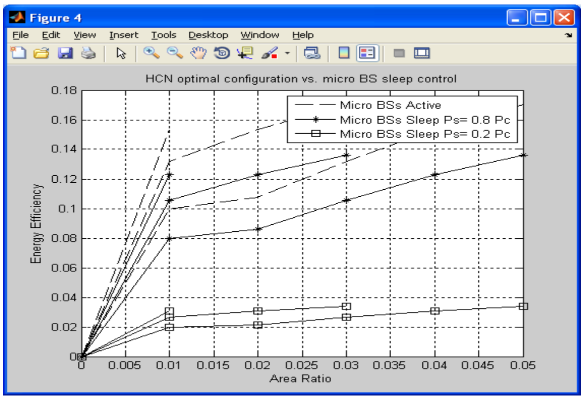


Figure 7:HCN optimal configuration vs micro base station sleep control

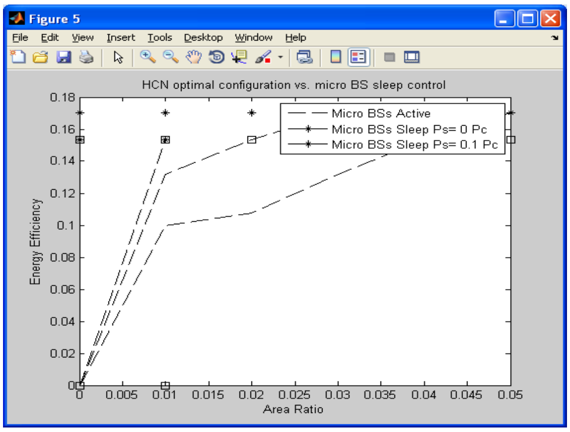


Figure 8: Energy efficiency vs area ratio

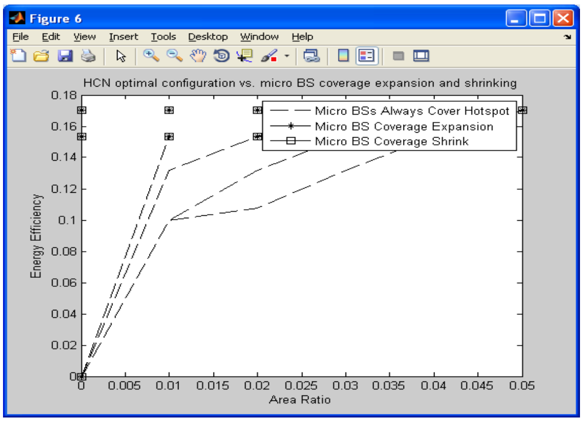


Figure 9: HCN optimal configuration under coverage expansion and shrinking control

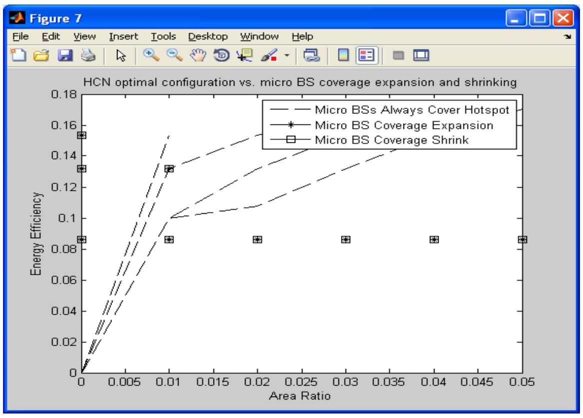


Figure 10: EE vs area ratio

The EE performance achieved by the HCN optimal configuration and under different values of $\gamma_m$and $\nu_m$is shown where both the theory curves and the Monte-Carlo simulation results are presented. In addition, the HCN EE first increases with $\nu_m$under small $\gamma_m$. Then HCN EE decreases under large $\gamma_m$. These results imply that the micro BSs should be turned on when HCN EE increases with $\gamma_m$and be put into sleep mode when HCN EE decreases with $\gamma_m$.

The simulation results of HCN EE achieved by the optimal configuration under different values of traffic rate ratio are shown. As can be observed from the figure, the HCN EE does not always increase with hotspot density $\lambda_h$. When $\lambda_h$ is relatively small, the HCN EE increases because the micro BS is more energy-efficient than the macro BS in terms of guaranteeing the coverage of hotspot regions. However, the interference of the micro BS diminishes HCN EE severely with increasing number of the micro BS and thus the HCN EE decreases when $\lambda_h$ becomes large.

The HCN EE achieved by the optimal configuration under different values of hotspot area is shown. The HCN EE does not always increase with hotspot density $\lambda_h$and the maximum value of HCN EE decreases with traffic rate ratio $\nu_m$, since larger area of hotspot regions also requireslarger transmit power of micro BS and leads to more severe interference.

The solid lines show the HCN EE achieved by the optimal configuration while the triangle-mark lines and the dashed lines show the micro BSs sleep control strategy.

## VI.CONCLUSION

The theoretical analysis are clearly identified, the base station implementations considering only the high traffic demands from large scale user is leads to increase global warming. This identification has been reported that the information communication technology infrastructure leads to 2% of $CO_2$ emissions, which is expected double by 2020. Every year 0.2% of global energy is consumed by mobile communication networks. So the green wireless communication is the most promising method for reducing energy consumption to meet the increasing traffic demands. In real Heterogeneous Cellular Networks (HCN), the ranges of transmit power for micro Base Stations and macro Base stations are 10mW ~ 2W and 5W ~ 80W.

The energy efficient design of heterogeneous cellular network based on large scale user behavior constraints is the better way to achieve optimal energy efficiency during high traffic demands. The closed-form formulas are establishes the quantitative relationship between large-scale user behavior and energy-efficient HCN configuration. In addition, proposed three energy-efficient control strategies of micro Base stations are used to reduce the transmit power need to meet the traffic rate, in which the area ratio($\gamma_m$), coverage ratio($\widetilde{\gamma_m}$), average spatial rate ratio($\widetilde{v_m}$)and traffic rate ratio($v_m$) are adjusted in macro and micro base stations. Simulation results validate the theoretical analysis and demonstrate that the proposed control strategies can potentially lead to significant improvement of HCN Energy Efficiency.EE is reduced with the traffic rate increase when HCN follows the homogeneous distribution at that time transmit power doesn't equal to traffic rate but the energy is saved during low traffic rate to meet the EE under high traffic conditions and also the macro and micro BS transmit powers are adjusted to meet the hotspot and non-hotspottraffic demands. The possible extensions of this work could include multiple antennas and bandwidth allocation for interference cancelation.

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