A Survey Report on Cell Zooming for an Energy Efficient Cellular Network

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***Abstract*—There is a prompt growth of cellular systemwhichhas decisiveissueto meet energy utilization. The cell zooming concept has been used in green cellular network to overcome the enormous energy utilization of the base station. This paper investigates various cell zooming methods which have flexibility to regulate the cell size based on the various traffic loads, channel status in sequence and the user status. The performance of cell zooming has been performed. The vital advantage of the cell zooming is to rescue energy in a cellular system. In this paper, the various energy efficient techniques and algorithms are discussed.**

***Keywords*— Cell Zooming, Energy Utilization, Green Cellular Network.**

I. INTRODUCTION

In present years, there is a tremendous growth in the cellular system; the energy utilization of cellular system is a vital issue. Because of the outstanding growth in the inhabitants, the Mobile Users (MU's) have been escalating, in order to accommodate the requirement of the MU's, the deployment of BS's has been rising. Because of this more energy utilization takes place in the BS's. Thus the energy utilization of BS's can be condensed by means of the cell zooming concept in the green cellular network.

The BS's acquires more energy in the cellular network. By using the cell zooming concept vigorously regulate the cell size according to the traffic load. The energy utilization has grow to be an important problem in the world, because the Carbon emissions of energy sources have great negative crash on environment and the cost of energy also increasing [1]. When a BS is in its working mode, energy utilization of processing circuits and air conditioner takes around 60%of total utilization.

Cell zooming technique is realized [2] by cell zoom in, to lessen the cell size while a cell is congested and cover only users present in the smaller area.Hence the overcrowding problem is liberated, while other users are provided coverage by cell zooming out the neighboring cells of according coverage hole.

Generally when the cells is less overcrowded switched off and users in the switched off cell's region is covered with cell zooming out the neighboring cells. The following techniques can be used to implement the cell zooming namely Physical adjustment, Relaying, BS co-operation and BS sleeping.

II. SYSTEM MODEL

The total system contains five same size [3] cells (Fig.1). Each cell have the BS's and mobile users(MU's).The BS's are to be found at the center the cells, each BS is consists of an antenna that are used to cover its geographic region. From the Fig.1the MU's denoted by solid dots and the BS's are denoted by hollow squares.

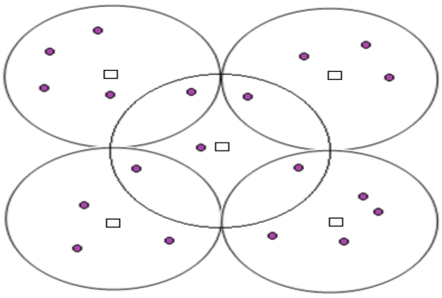

Fig .1 Cells are with original size

In general, when the load increases the cells will 'zoom in'. Here this (Fig.2) MU's arriving towards the central cell, so central cell gets overcrowded. When the cells get zoom in, the MU's will free fromcell, so cells will be overcrowded and also MU's will not get the coverage.

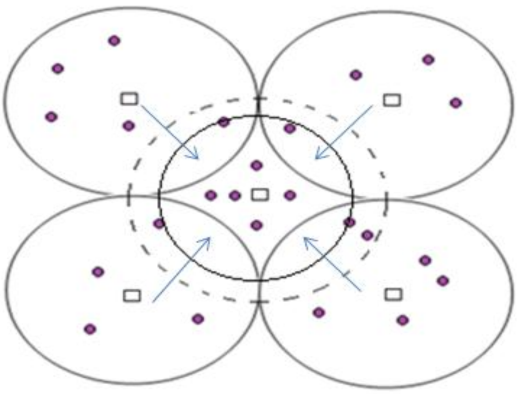

Fig.2 when the load increases the cells will 'zoom in'

When the load decreases the cells will 'zoom out' (Fig.3).Here this MU's are moving away from the central cell, so cells will be overcrowded and also MU's will not get the coverage.

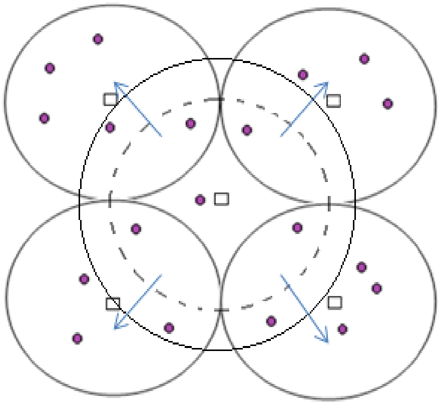

Fig.3Whenthe load decreases the cells will 'zoomout'

In this case (Fig.4) the neighboring cells can either zoom out to take care of the coverage. The central cell chooses to reduce the energy consumption of the BS's.

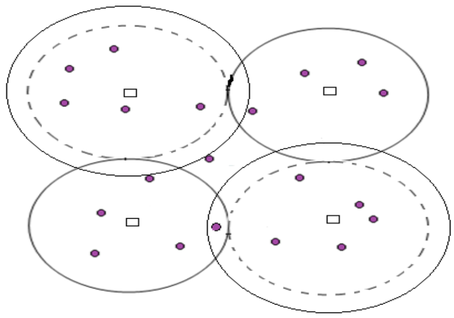

Fig.4 cell sleeps and neighbouring cells zoom out

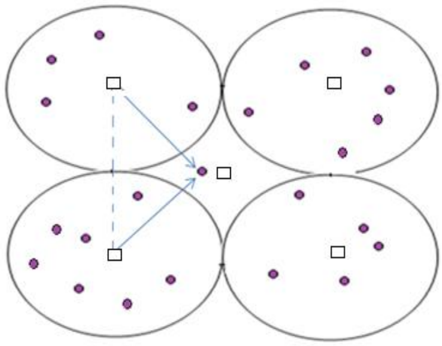

Fig.5Central cell sleeps and neighbouring cells transmit cooperatively

From this (fig.5) the central cell will be sleeps and neighboring cells transmit sharing to others.Simulation outcome illustrate that cell zooming leads to considerable energy savings of up to 40% while maintaining coverage during off-peak hours. Furthermore, when demand increases, the base station can quickly return to its full coverage state. This paper [4] is focusing on different cell zooming algorithms such as continuous, discrete, centralized algorithm, distributed algorithm and fuzzy methods.

III . CENTRALIZED ALGORITHM

Centralized algorithm mostly based on the allocation and reallocation of users [5]. The MU's feedbacks channel conditions and rate requirements to the BS's through the coordination stages.The main idea of the centralized algorithm is to switch OFF the base station under the light load and switch ON the base station under the heavy load as for as possible.The traffic load (L_j), is defined as the ratio of summing up of the user bandwidth (b_{ij}) and the total bandwidth of the base station [5],

$$L_j = \sum_{i \epsilon M_j} \frac{b_{ij}}{B_j} \qquad ...(1)$$

Where L_j denotes the traffic load at the base station 'j'. The matrix of user location is defined as X= [X_{ij}] where the X_{ij}=1 when user i, allocated to the base station 'j' and X_{ij}=0 when the user is not allocated under the base station j. The idle bandwidth for BS $_j$ is given by[5],

$$\text{Idle bandwidth} = (1 - \alpha_j)\, B_j \qquad ...(2)$$

Where $\alpha_j$is reservation factor for each mobile user the constraints.

$$L_jB_j + b_{ij} \leq \text{idle bandwidth} \qquad ...(3)$$

Where B_j is user idle bandwidth. User reallocation is done by the base station when that going to serve as sleeping mode. When the ratio of LjBj /idle Bj is achieving least value it shows base station goes to sleep mode.

The first step includes checking for bandwidth constraint. Depending upon the spectral efficiency of the base stations, the users are allocated to the base station with highest spectral efficiency (N: Number of users).

IV. DISTRIBUTED ALGORITHM

In the distributed algorithm, base stations preserves bandwidth for newly arrival mobile users from centralized algorithm. It used to reduce the information exchange and signaling overhead. In practice, traffic load information and bandwidth reservation parameters can be obtained by broadcasting control signals between base stations.In practice, traffic load information and bandwidth reservation parameters can be obtained by broadcasting control signals from BSs. Intuitively, each MU will select the BS with high load and high spectral efficiency. We define a preference function if MU *i* is to be associated with BS *j* as

$$U(\omega_{ij}, L_j, \alpha_{ij}) \begin{cases} \frac{\omega_{ij}\,(L_jB_j + b_{ij})}{\tilde{B}_j} & L_jB_j + b_{ij} \leq \tilde{B}_j \\ 0 & L_jB_j + b_{ij} > \tilde{B}_j \end{cases} \qquad ...(4)$$

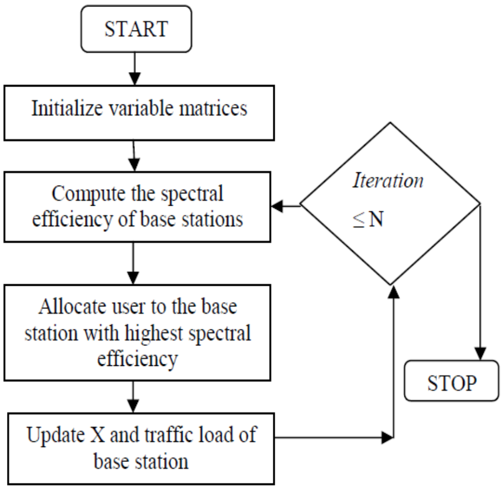

Fig.6 Flow chart for use allocation in distributed algorithm

The MU's prefer the BS's with high spectra efficiency, but load cannot exceed a predefined threshold. The method of distributed cell zooming algorithm (Fig.6) is described as follows.

- Step1: Initialize all the Lj to be 0 and all elements in matrix to be 0.
- Step2: For each MU i ,find the set of BS's who can serve MU i without violating the bandwidth constraints which means,

  $L_jB_j + b_{ij} \leq$ idle bandwidth ….(5)

  If the set is empty, $MU_i$is blocked otherwise, associate MU_i with aBS_j, where j[th] BS has the highestspectral efficiency (**U** (ω_{ij},Lj,$_{\alpha\, j}$)).
- Step3: Replicate the step 2 until there is no undated of X. then output X and end practice.

In the distributed algorithm, there is no co-ordination among the BS is needed, therefore abundant signaling overhead is reduced.It works in an iterative way. The convergence of the distributed algorithm is guaranteed if any two MUs take no action simultaneously. This is because the BS selection set of each MU is finite. After the algorithm converges, the BSs with no association will work in sleep mode during the serving stage.

V. CONTINUOUS CELL ZOOMING METHOD

Continuous method of cell zooming technique is based on a BS transmitting at the power level that is just sufficient to reach its farthest user. Thus a BS dynamically grows (up to r_{max} or shrinks (potentially to zero) its cell radius to just accommodate the farthest user within its boundaries. With cell zooming, assumeP_r to be a fixed required power for the farthest user (at a distance r_x) and the BS required transmission power P_{cont} is therefore given by:

$$P_{cont} = k\, r_x^{\,n} \qquad ....(6)$$

The transmitter power is proportional to the *n*th power of the distance of the farthest user in the cell. Continuous transmit-power adaptation is the most energy efficient cell zooming approach, but implementation of this method is challenging because of high user mobility and requiresrobust location feedback**.**

VI. DISCRETE CELL ZOOMING METHOD

With discrete cell zooming, the BS transmit power is chosen from only a discrete set of allowable values. The cell area is divided into *Z* number of zones with *r(i)* being the radius on the i^{th} discrete zone and *i* ranging from 1 to *Z.* Assume that the farthest user is located between two discrete levels *r(i)* and *r(i+1).* The BS chooses to transmit power based on the higher discrete level of radius *r (i+1)* to provide coverage to all users including the edge users in that particular zone. The advantage of discrete cell zooming is in the reduced location feedback necessities. The mobile user need not report its location information to the BS until it crosses one discrete zone to the next. By increasing the number of zones *Z,* the BS increases its energy savings at the cost of increased feedback complexity.This paper proposes three different methods of obtaining the allowable discrete radius values*r (i)* a detailed description of each method is discussed in the following sections**.**

A. IMPLEMENTATION OF DISCRETE CELLZOOMING

There are many steps involved in the implementation of cell zooming. Flowchart Shown in Fig.7 represents the ways to divide the entire coverage area into discrete levels by using three different methods. Detailed description of each step is as follows:

Step1: Initialize with the coverage area r_{max}, number of zones, type of division method used and fuzzy percentage region and radius of the distant user r_{dist}

Step2: Choose the type of mode to be used (i.e.) type of division method used to divide the coverage area.

Step3: Calculate the radius of the each discrete level using various discrete division Methods. The number of discrete levels depends on the number of zones to be divided.

Step4: Check for the condition that if the radius of the distant user is within the discrete level say (i), then radius of the discrete level will be equal to the radius of the user.

Step5: If the mode used is fuzzy, then check whether the radius of the distant user is greater than the radius of the current discrete level say (i) and lesser than next discrete level (i+1) in addition to the fuzzy boundary region. If it is true then the radius of the user will be equal to the radius of the next discrete level.

Step6: If it is not true then check whether the radius of the distant user is greater than the radius of the next discrete level say (i+1) and lesser than next discrete level (i+1) in addition to the fuzzy boundary region. If the condition is true then the radius of the user will be equal to the radius of the next discrete level otherwise radius will be equal to next higher discrete level.

Step7: The average number of users in the network can be calculated based on the simulation time used. The random distribution of both the data and voice users are computed.

Step8: The Poisson distribution can be computed based on the inter arrival time and number of users in the network. The arrival call arrival instance, hold time and termination are computed based on the Poisson distribution.

Step9: If the user arrival time is greater and the extinction time is lesser than the simulation time, then BS will provide service to that user.

Step10: BS transmits power can be computed based on the zone value designed using discrete and fuzzy cell zooming methods. The value of the zone various for different type of division method used and hence the BS transmit power.

VII.LINEAR DIVISION METHOD

In linear division method, the maximum cell radius r_{max} is divided into uniformly spaced levels. In this method, the area of each zone (the number of users covered) increases with the level *i* shown in Fig 8. The discrete level of radius using LDM is calculated by using the equation:

$$r(i) = i r_{max}/Z \quad \text{.. ..(7)}$$

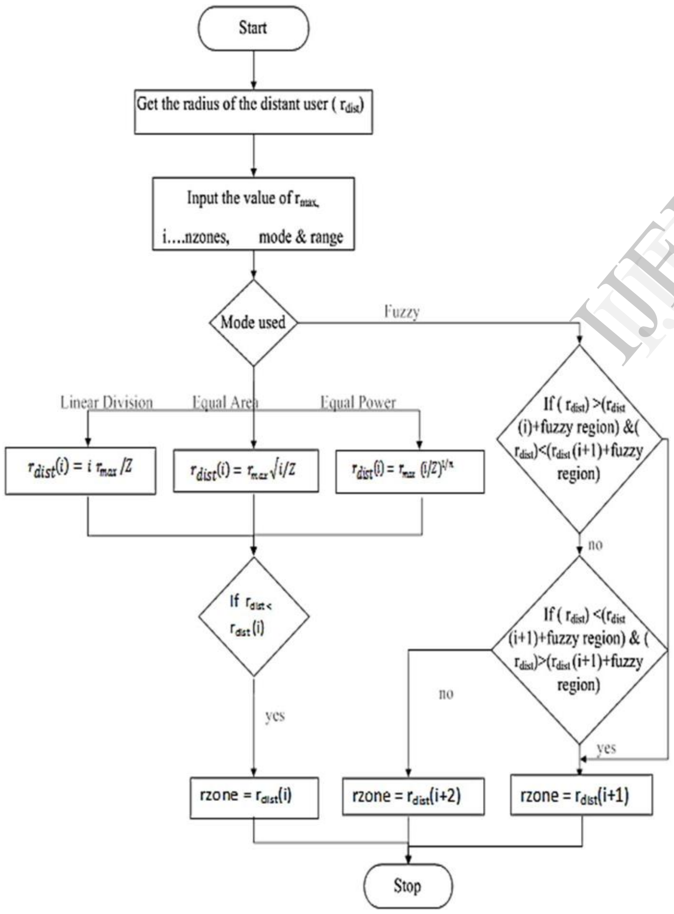

Fig.7 Flowchart represents discrete cell zooming methods.

The transmission power of the BS using Linear Division Method can be considered using the equation.

$$P_{LDM} = k\, r\, (i_x)^n \quad (8)$$

Here $P_{LDM}$is the power to be transmitted by the BS using a linear division of the cell andr(i_x) is the radius of the zone with the farthest user

In this method, the cell is divided into *Z* discrete zones with equal area in each of the zones .Since the area covered by each zone is equal, so that user distribution will be equal (on average) in every zone. In this method, thei^{th}discrete level ofradius r(i) is obtained by using the equation:

$$r(i) = r_{max}\sqrt{i/z} \quad \text{...(9)}$$

The transmission power of the BS using EADM can be computed using the equation:

$$P_{EADM} = k\, r\, (i_x)^n \quad \text{... (10)}$$

Where, $r(i_x)$ is the radius of the zone with the most distant user. Since this method divides the cell into equal area zones, radii of the first few zones will be more when compared to theLinear Division Method and hence power consumption is also more when the farthest user is still not far from the BS.

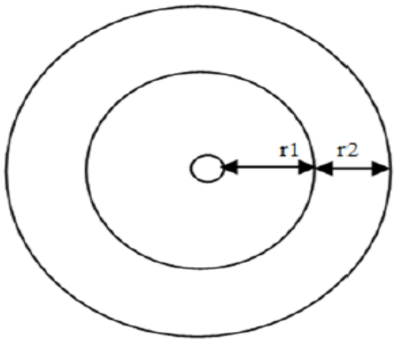

Fig.8 Equal area division method

VIII. EQUAL POWER DIVISION METHOD

In this method, the cell is divided into discrete zones with equal BS transmission power (Fig. 9) increments for each zone. The transmission power for the i^{th} is zone is equal to iP_{max}/Z. The area of each zone is not the same as compared to the Equal Area Division Method. Since we have used a path loss exponent *n=4*. From the propagation equation i^{th}discrete level of radius is calculated by using the equation:

$$R(i) = r_{max} (i/Z)^{1/n} \quad \text{...(11)}$$

The transmission power P_{EPDM} of the BS using Equal Power division method can be calculated using the equation:

$$P_{EPDM} = k\, r\, (i_x)^n \quad \text{...(12)}$$

Where $i_x$is the radius of the zone with the most distant user. In this method, the number of zones increases as we move towards to the edge of the cell. The area of the first zone is higher when compared to the Equal Area Division Method and so there is an increase in level of power consumption when compared to the other methods at low demand.

IX. FUZZY CELL ZOOMING METHOD

Fuzzy cell zooming method is an extension of the discrete cell zooming method with a small (about 10% to 20%) increase in the range of coverage at each discrete level and a slight compromise in received signal to interference and noise ratio (SINR) for the users located beyond the corresponding discrete level of radius. This technique is based on checking the boundary conditions of the users along with an extension of coverage range as explained next.

[5] In Fig.10the shaded portion shows the fuzzy region with a radius of about 10% or 20% in excess of the corresponding *r(i)* instead of transmitting at the next higherDiscrete level of radius *r (i+1)* the transmission power of the BSs using fuzzy model can be calculated using the equation:

$$P_{fuzzy} = k\, r\, (i_x)^n \quad ..(13)$$

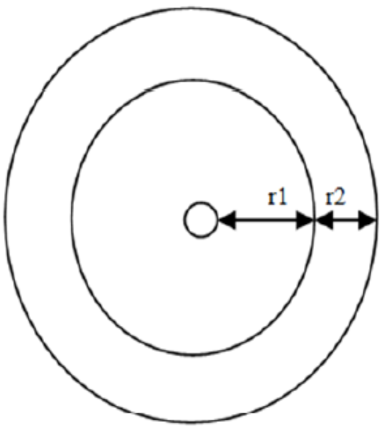

Fig.9 Equal power division method.

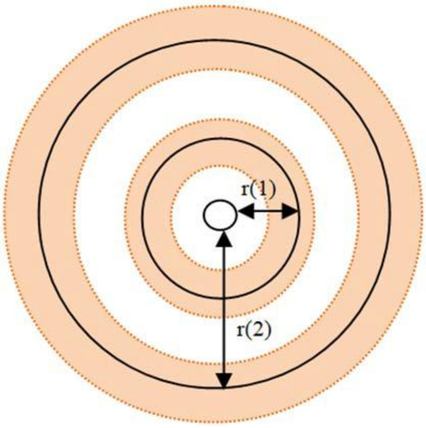

Fig.10Fuzzy discrete model

Here $P_{fuzzy}$is the power transmitted by BS using fuzzy model and *r(i $_x$)* is the radius of the zone which contains the farthest user within its 10% (or 20%) fuzzy region. Fuzzy cell zooming method performs better than the discrete cell zooming method since the BS transmits at the current discrete level of radiusr(i $_x$) instead of switching to the next higher level. The received SINR, however is slightly lower than the desired value in the fuzzy region and hence has to be compensated for by using more powerful error correction coding techniques.

Table 1. Comparing all technique with respect to energy efficiency

Techniques	No. of Users	Energy Efficiency
Continuous cell zooming method	200	50%
Equal Power Division method	200	60%
Discrete cell zooming method	200	65%
Fuzzy cell zooming method	200	68%
Linear Division method	200	75%

From the Table1, it is clear that linear division method has a maximum efficiency of power about 75% while compare with all the above techniques. Hence linear division method can reduce the power consumption in the network.

X. CONCLUSION

In this paper,various techniques of cell zoominghas beeninvestigated in accordance with adaptively adjust the cell size depending onthe traffic load fluctuations. The cell zooming techniques provides the solution for traffic load imbalance as well as reduces the energy consumption in the cellular network. Finally the fuzzy cell zooming method performs better energy consumption than the other various techniques.

REFERENCES

[1] Z. Niu, YanqunWu, J. Gong and Z. Yang, "Cell zooming for cost-efficient green cellular networks", IEEE Commun. Mag., vol. 48, no. 11, pp. 74–79, Nov. 2010.

[2] X. Weng, Dongxu Cao and Z. Niu, "Energy-efficient cellular network planning under insufficient cell zooming", in Proc. 73rd Vehic. Technol. Conf., Budapest, Hungary, pp. 1–5, 2011.

[3] V.Prithiviraj, S.B.Venkataraman and R.Vijayasarathi ''Cell zooming for energy efficient wireless network", Journal of green engineering, vol.3, 421-434, Sep2013.

[4] R .Balasubramaniam, S.Nagaraj, M.Sarkar, C.Paolini and Paras and Khaitan, ''Cell zooming for power efficient base station operation".2013 IEEE.

[5] Rinju Mariam Rolly, PoornimaSabu "Performance Analysis of cell Zooming Network",International journal of research in advent tech, Vol, 1, 2, No.5, May 2014.

[6] S. Bhaumiket al., "Breathe to stay cool: Adjsuting cell sizes to reduce energy Consumption," in Proc. ACM Mobicim, Special Workshop on Green Networking,New Delhi, India, 2010, pp. 41-46.

[7] A. Amannaet al., Metrics and Measurement Technologies for Green Communications.Gaithersburg, MD: National Institute of Standards and Technology, 2009.

[8] Hasan, Z., Hamidreza B. and Vijay K., "Green Cellular Networks: A Survey, Some Research Issues And Challenges", Communications surveys and tutorials,IEEE,Vol. 13 ,pp 524-540,Nov 2011.

[9] Md. FarhadHossain, Kumudu S. Munasinghe and Abbas Jamalipour," A Protocooperation-basedSleep-Wake Architecture for Next Generation Green Cellular Access Networks,"IEEE ICSPCSInternational Conference,pp. 1-8, Dec 2010.

[10] Kyuho S., Hongseok K., Yung Y. and Bhaskar K., "Base station operation and user associationMechanisms for energy-delay tradeoffs in green cellular networks," IEEE Journal on selected areas inCommunications, Vol. 29, No. 8,Sept 2011.

[11] J. T. Louhi, “Energy efficiency of modern cellular base stations,” Proceedings of IEEE InternationalTelecommunications Energy Conference (INTELEC), Italy, pp. 475 – 476, September 2007.
[12] Lin Xiang, Francesco Pantisano, Roberto Verdone, XiaohuGe, Min Chen,“ Adaptive Traffic Load-Balancing for Green Cellular Networks,” IEEE PIMRC , pp. 41-45, Sept 2011.
[13] Fred Richter, Albrecht J. Fehske, and Gerhard P. Fettweis,” Energy Efficiency Aspects of Base StationDeployment Strategies for Cellular Networks,” IEEE Vehicular Technology Conference,pp. 1-5,Sept2009.
[14] PriyangshuGhosh, SuvraSekhar Das, SwethaNaravaram, PrabhuChandhar, “Energy Saving inOFDMA Cellular Systems Using Base-Station Sleep Mode: 3GPP-LTE a Case Study,” NationalConference on Communications, Feb 2012, in press.
[15] K. Son, H. Kim, Y. Yi, and B. Krishnamachari, “Toward energy-efficientoperation of base stations in cellular wireless networks,” a book chapterof Green Communications: Theoretical Fundamentals, Algorithms, andApplications (ISBN: 978-1-4665-01072), CRC Press, Taylor & Francis, 2012.
[16] M. A. Marsan, L. Chiaraviglio, D. Ciullo, and M. Meo, “Optimal energy savings in cellular access networks,” in Proc. IEEE GreenComm. Dresden, Germany, June 2009.
[17] P. Rost and G. Fettwes, “Green communications in cellular networkswith fixed relay nodes,” Cooperative Cellular Wireless Netw. Sept.2010.
[18] K. Son, E. Oh, and B. Krishnamachari, “Energy-aware hierarchical cellconfiguration: from deployment to operation,” in Proc. IEEE INFOCOMWorkshop Green Commun. AndNet. Shanghai, China, Apr. 2011.
[19] L. Correia, D. Zeller, O. Blume, D. Ferling, Y. Jading, I. Godor, G. Auer,and L. Van Der Perre, “Challenges and enabling technologies for energyaware mobile radio networks,” IEEE Commun. Mag., vol. 48, no. 11,pp. 66–72, Nov. 2010.
[20] K. Son, H. Kim, Y. Yi, and B. Krishnamachari, “Base station operationand user association mechanisms for energy-delay tradeoffs in greencellular networks,” IEEE J. Sel. Areas Commun., vol. 29, no. 8, pp.1525–1536, Sept. 2011.