International Journal of Advanced Information in Engineering Technology (IJAIET) ISSN: 2454-6933
Vol.3, No.12, December 2016

Power saving nature of cell zooming technique

A dynamic approach

Rinju Mariam Rolly
Department of Electronics & Communication
Mar Baselios College of Engineering & Technology
Kerala, India

Poornima S.
Department of Electronics & Communication
Mar Baselios College of Engineering & Technology
Kerala, India

***Abstract*—Base station is one among the important components that affects the energy efficiency of cellular networks. The algorithm aims at showing the variation in the cellular data. Here, the paper describes how the traffic, power consumption is varying from time to time in a daily basis. The result proves that the energy consumption varies dynamically according to the time, implies the possibility of energy conservation with the implementation of cell zooming method.**

***Keywords*— Energy efficiency; base station; power consumption; traffic analysis; user allocation;**

I. INTRODUCTION

Every designer aims at making the system more effective. When it comes to the mobile network, the efficiency depends upon the operational performance of the components. The importance of energy conservation and the increasing demand for enough resources is given in [1]. For the sustainability of cellular network, large amount of power is required. Cell zooming is intended to apply on those regions of the cellular network where the traffic intensity is light. It is meant to work with the new generation cellular networks such as LTE, 4G, 5G, etc. In traditional base station operation that is implemented right now, operates throughout the week, i.e., 24*7 hours a week. In such cases, the effectiveness in the energy utilization is very small and it results in the wastage of valuable energy resource. Green cellular networks can be achieved if it is able to save energy during those light traffic conditions. Switching off some base stations at light traffic scenarios would not affect the quality of service provide by the cellular operators.

Cell zooming based on physical adjustment adjusts the power transmitted by the base station according to the traffic experienced in the cell and the power variation in effect will result in the variation to the coverage radius of the base station. It is just not for weekends; but also in every day the traffic profile has got an interesting variation as shown in figure 1. If it is the case, think of the energy that can be saved by the implementation of cell zooming in the real cellular architecture. A sinusoidal traffic pattern [2] is assumed here.

Cell zooming is a technique to adaptively adjusts the cell size according to traffic conditions. It has the potential to balance the traffic load and reduce the energy consumption. When a cell is congested, the cell can zoom in to reduce the cell size and therefore release from the congestion and the neighboring cell zooms out to avoid any possible coverage hole. Cell zooming can be implemented by adjusting the physical parameters such as the transmit power of base stations, or by base station cooperation and relaying. [3]

The traffic profile is modeled as a periodic sinusoidal profile with unit mean M and variance V. D denotes the duration, i.e., 24 hour and Φ denotes the period.

$$u(t) = V cos\left(\frac{2\pi(t+\emptyset)}{D}\right) + M \qquad \text{Eq. (1)}$$

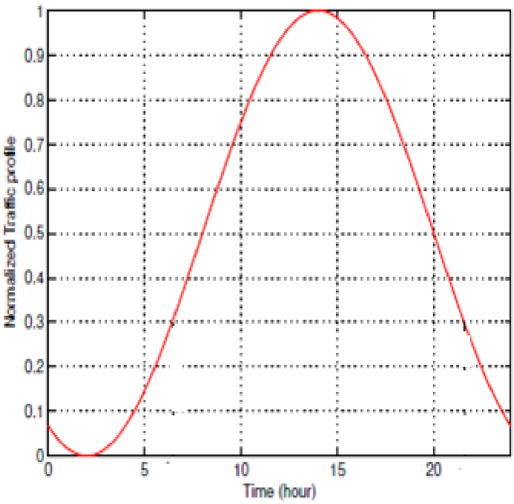

Fig. 1. Sinusoidal traffic pattern [2]

II. RELATED TECHNOLOGIES

Power savings through zooming concept is an ongoing research field. The research works starts by simply switching off the base stations. After rectifying the defect of complete switch off, sleeping and dimming techniques emerged. Again, each work varies with the method of sleeping the base stations. Energy saving will be maximized with maximized number of sleeping base stations. Works in [4-8] aims at the energy saving in the cellular network. [4] shows the switching of BSs based on a threshold, whereas [5] was about optimizing the cell size. [6] is new type of method called 'dimming'. [7] considers a zoning method, where the cell region is divided into several zones and power of base station is determined based on the distance of farthest user.

When the base station operates with the same transmission power, then the power it requires for the operation also remains same. All the base stations are initially designed such that it can support the maximum number of users estimated. Estimation study is done during designing period and a number of maximum users are predicted. The maximum transmission power is determined based on maximum users. As a result, a fraction of transmission power is wasted when the number of users is less than the predicted value. The paper proves the variation in the power consumption and the number of users based on a traffic pattern.

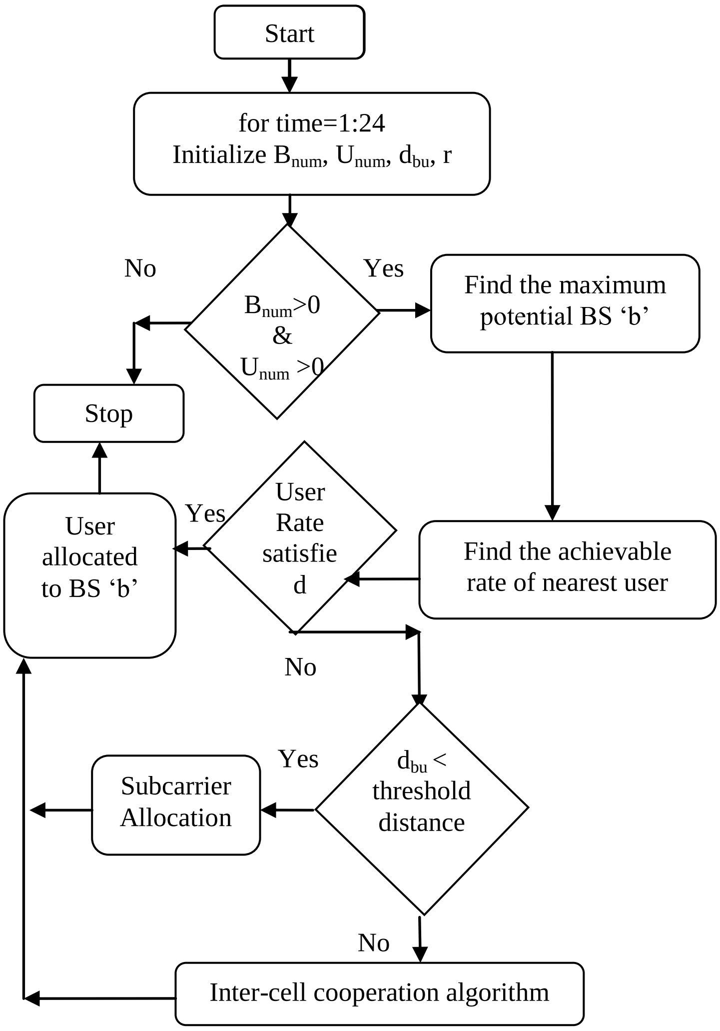

Fig. 2. Algorithm Flow Chart

III. SYSTEM DESIGN

Figure 2 shows the flow chart for the algorithm used. A cooperated cell network is shown in figure 3. Inter-cell cooperation (ICO) is the latest introduced technique with the purpose of mitigating the interference that may arise with power variation in the base station. Inter-cell cooperation deals with the cooperation among the cells. It is almost similar to the concept of base station cooperation. Since cooperation is considered, it is assumed that full channel state information is available. The users are randomly located; whereas the base stations are positioned with uniform distance apart based on ideal hexagonal cell layout.

Usually or even in the present cellular technology, each user is serviced only by a single base station. So that in such cases when the users is beyond the coverage zone of that base station, the user cannot be served and it remains untouched with the cellular connection link. For a mobile user to get the cellular services, it is very essential that the particular user should be under the footprint of a base station. The signal strength degrades with the increase in the distance and as a result the users at the cell boundary will experience weak signal strength. Thereby most of the remote end users will remain un-serviced.

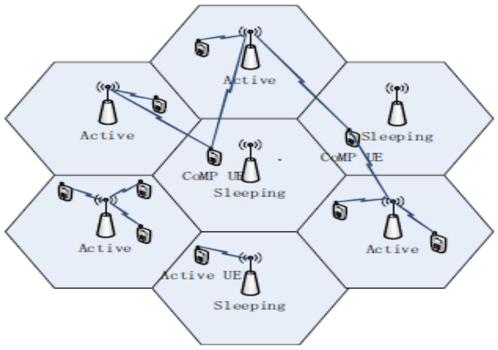

Fig. 3. Inter cell cooperation with power control [2]

A. Cooperation Technique

Inter-cell cooperation can solve the problem of weak signal strength experiencing by the users at the cell boundary. This is because of the adding up of signal strength in inter-cell cooperation technique. Adding up can take place only if the signal transmission happens over the same carrier frequency. Since the proposed cell zooming technique is meant for the new generation cellular networks, the concept of OFDM has to be referred for channel allocation. OFDM consider orthogonal frequency channels and hence the correlation between the subcarrier frequencies is almost zero according to the orthogonal property. The whole spectrum is divided into a number of sub channels named 'subcarrier frequencies'. Say, if the total available bandwidth is 3MHz, then based on the demand the spectrum can be cut down into a number of channels. For example, 300 subcarriers are possible, with individual subcarrier bandwidth of 10 KHz. By this concept, it is possible to allocate the entire frequency spectrum to each cell. Also each of these subcarrier channels would not interfere with each other because of orthogonality or in other words, the channel splitting is done by satisfying the principle of orthogonality.

B. Channel Modelling

The way the signal affects travelling through a misty environment is different from a travelling a sunny day. Similarly, how the signal would be affected depends upon the type of channel the signal met. The factors that have to analyze for a laser communication is not the same as for a mobile network. That shows depending upon the channel, even the factors that have to be analyzed also changes. Hence each channel is unique in its performance and in the way it maintains the transfer of signals.

A channel model is like a complete readymade set. Parameters vary for each channel model depending upon their circumstances. These models can help us in simulating cellular networks, for it is very crucial to consider the effect of signal transmissions on urban areas, sub-urban, open areas, shadowed regions, indoor environment, etc.

The received power for reflection model [9] is given as,

$$|P_r| = P_t \frac{G h_t^2 h_r^2}{d^4}$$ Eq. (2)

The channel model equation for the Hata model is defined in [10]. Linear model is the path loss model. Power received varies depending upon the channel models.

IV. RESULT AND DISCUSSIONS

A Matlab simulator is used to consider a 10 by 10 square grid model. The time varying effect is considered for 24 hour duration scale.

Energy saving ratio= $(P_a\text{-}P_s)*N_s / (P_a*B_{total})$ Eq. (3)

Power consumption= $P_a*N_a + N_s*P_s$ Eq. (4)

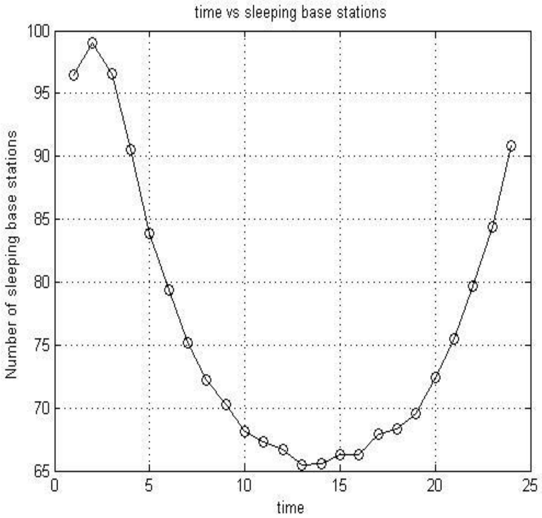

Fig. 4. Number of sleeping base stations

Energy saving ratio and power consumption is considered for the evaluation of system operation. The method saves enough energy with the increase in the number of sleeping base stations. Pa=400W and Ps=10W denote the power consumed by base station during active and sleeping mode respectively. Similarly, Na and Ns denote the number of base stations at active and sleeping mode respectively.

A sinusoidal traffic model is assumed for the simulation as shown in figure 1. Figure 4 shows the number of sleeping base stations in the network based on the sinusoidal traffic profile. As a result depending upon the model the user density available at each time instant is varying. Power consumption by the base station and the number of sleeping base stations holds an inverse relationship. When high traffic refers to the increase demand of users, it results with reduced number of sleeping base stations.

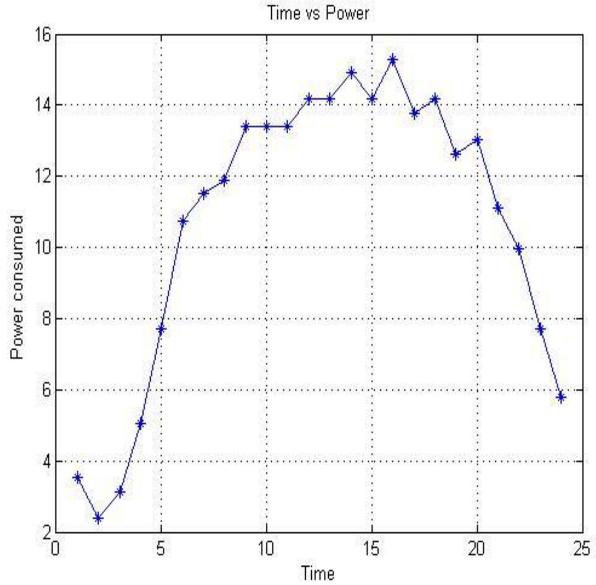

Fig. 5. Power Consumption graph w.r.t to Time

Figure 5 shows the increase in power consumption of base station in the day time and lesser power consumption in off time periods.

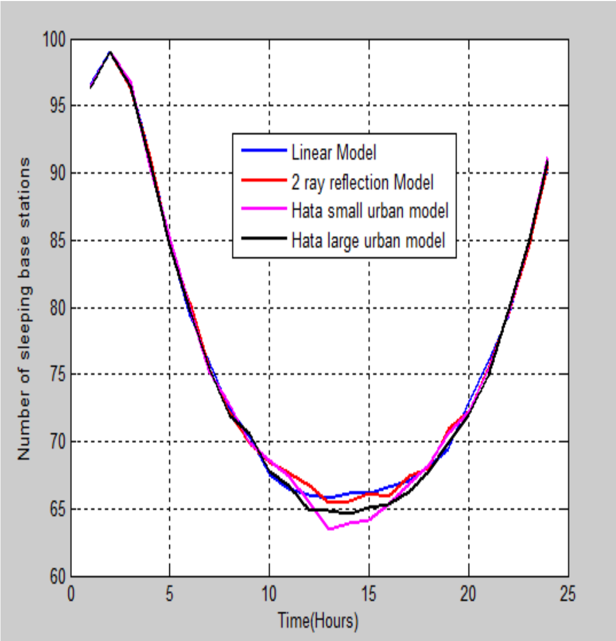

Fig. 6. Number of sleeping BSs for varying channel models

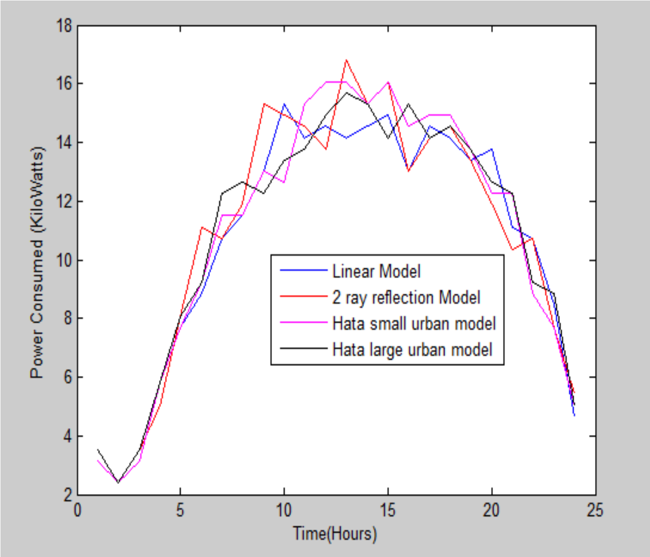

Fig. 7. Comparison of Power consumption for different channel models

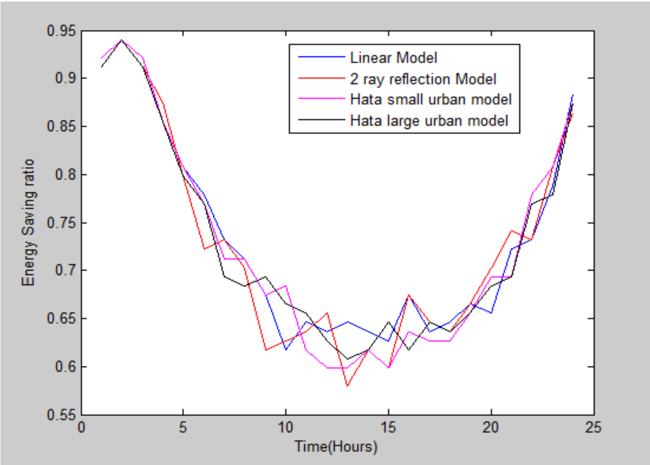

Fig. 8. Energy saving ratio comparison for different channel models

V. CONCLUSION

The performance of zooming technique is analyzed for a traffic profile which follows a dynamic nature. The results clearly shows the amount of energy that can be saved by considering cell zooming. The performance is compared for several channel models. Among the defined channels linear path model performs better than other models, this is because other models consider some practical effects also.

ACKNOWLEDGMENT

I thank my Lord almighty for the strength he blessed me with. I would like to extend my gratitude to my guide, faculties, friends, to my family and to all who supported me in this work sincerely.

REFERENCES

[1] Chethana R Murthy and Dr. C Kavitha, "A Survey of Green Base Stations in Cellular Networks", in International Journal of Computer Networks and Wireless Communications (IJCNWC), ISSN: 2250-3501 Vol.2, No.2, April 2012.

[2] Pei Yu, Qinghai Yang, Fenglin Fu, Kyung Sup Kwak, "Inter-cell Cooperation Aided Dynamic Base Station Switching for Energy Efficient Cellular Networks", in IEEE Trans., October 2012, pp. 159-163.

[3] Zhisheng Niu, Yiqun Wu, Jie Gong, and Zexi Yang, Tsinghua University.,"Cell Zooming for Cost-Efficient Green Cellular Networks," IEEE Commun. Mag., vol. 48, issue.11, Nov. 2010, pp.74–79.

[4] Eunsung Oh, Kyuho Son, and Bhaskar Krishnamachari, "Dynamic Base Station Switching-on/off Strategies for Green Cellular Networks", IEEE Transactions On Wireless Communications, Vol. 12, No. 5, May 2013, pp. 2126 - 2136.

[5] Sourjya Bhaumik, Girija Narlikar, Subhendu Chattopadhyay and Satish Kanugovi, "Breathe to Stay Cool: Adjsuting Cell Sizes to Reduce Energy Consumption," in Proc. of ACM Mobicim, Special Workshop on Green Networking, August 2010.

[6] Tipper, D., Rezgui, A., Krishnamurthy, P. and Pacharintanakul, P., "Dimming Cellular Networks", IEEE Global Telecommunications Conference, pp. 1 – 6, 2010.

[7] R. Balasubramaniam, S. Nagaraj, M. Sarkar and C. Paolini, Paras Khaitan, "Cell Zooming for Power Efficient Base Station Operation", in IEEE Wireless Communications and Mobile Computing Conference, April 2013, pp.556-560.

[8] Rinju Mariam Rolly, Poornima S., "Performance Analysis of Cell Zooming Network", in International Journal of Research in Advent Technology, ISSN: 2321-9637, Vol.2, No.5, May 2014.

[9] http://en.wikipedia.org/wiki/2-Ray_Ground_Reflection_Model

[10] http://en.wikipedia.org/wiki/Hata_Model_for_Urban_Areas