Energy-Efficiency for Heterogenous Wireless Networks by using Hand-off Approach

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***Abstract*—With the dense use of smart phones, the global mobile data traffic has increased from 0:2exabytes/month in 2010 to 2:5exabytes/month in 2014. With a growth of 1150% over 4 years it is expected that global mobile traffic will increase by a factor of 10 between 2014 and 2020 [1]. Mobile Base station (BS) cell sites consumed over 60% of the company total energy consumption for most mobile carriers, therefore current research has a significant focus on improving the energy efficiency of mobile access networks. In recent years, the increasing impact of networks on the environment has made energy efficiency in telecom networks an important theme for researches. In this context, heterogeneous wireless networks (HetNets) plays a key role in 4G and 5G due to offer easily access services anywhere and anytime. Our study is developed based on IPv4 protocol but our developed algorithm can apply too IPv6 easily. In this paper, we propose a new approaches which provides more energy efficient than Green Joint Radio Resource Management (JRRM) Architecture. Our proposed model has 2 stations, which are separated from each other. One of them, which is called macrocell, addresses the control of a vast territory. The other is located in more sophisticated and local areas. All calls come to the macrocell at first. According to the intensity of call rate microcells turn on or off. These actions are performed by a threshold located in the macrocell. Control of the macrocell achieves a good level of energy efficiency. As it is showed in the illustrations, Handoff Green JRRM Architecture is better than Green JRRM Architecture in the aspect of energy-saving, in any case. The energy-saving action changes the range from 45% to 70% in an average traffic load. Handoff Green's Dynamic Coverage Management (DCM) algorithm promises more opportunities in saving energy. Using a Markov model, the diagram of the states transitions is represented and some obtained performance results are showed by the figures.**

Keywords-Energy efficiency; HetNets; joint radio resource management (JRRM); macrocell and microcell occupancy; green network design; threshold macrocell and microcell; Markov process; performance.

I. INTRODUCTION

In this paper, we have proposed a new algorithm for conserving energy in wireless networks which will be benefit economically for the power industry. The reason of these improvements to wireless networks is that the world of mobile communication growing at an amazing rate. Nowadays, Information Communication Technologies (ICT) consumes a significant portion of all energy that is produced in the world. It seems that ICT will continue to increase in the consumption of energy for many years to come. Due to this forecasted increase in energy consumption in the future, it is vital importance that some energy-saving actions must be taken in consideration. Furthermore, if precautions are not taken soon to improve this situation, there will be enormous negative effects on the environment. The production of electrical energy releases harmful gases that contribute to the Greenhouse Effect on the atmosphere. It is imperative that we make an effort to decrease this energy consumption as much as possible. One solution is finding "greener" ways to produce electricity, and another is to develop new technologies and methods of reducing the consumption of energy. In this paper, we have focused on the ways in which the consumption of electrical energy can be reduced.

The current forecasts predict that by 2018, high-speed coverage will reach over 85 percent of the world's population, and global traffic in mobile networks are going to rise with a compound annual growth rate (CAGR) of 50 percent, reaching a 12-fold increase since 2012 [2].

Nowadays, heterogeneous wireless networks (HetNets) 4G or 5G wireless networks allow to reach access services in everywhere and every time, the ICT carbon emission is comparable to that of the global aviation industry [3]. By 2020, this emission is foreseen to grow at a rate of 3.8 percent, expecting to contribute 2.3 percent of the global greenhouse gas emissions, which represents 1.27 $GtCo_2e^1$ [4]. The important part of this energy is consumed by Base Stations (BSs) [1]. This consumption is approximately 57% of the whole energies used by all ICT sector [5].

In our study, while lowering energy consumption we have to keep the performance of the system at acceptable level. Our developed algorithm defines a threshold value as a certain percentage of the whole capacity of the system. If the number of calls is lower than the defined threshold, the calls are accepted by macrocell and microcell is kept off. If the number of calls is equal or higher than the defined threshold, Calls are assigned to microcells from that are coming. The most engaged microcell is activated and its calls are transferred to their microcell. If microcell occupancy falls under predefined microcell threshold, the microcell transfers its calls to macrocell and closes itself. If microcell occupancy is greater than its threshold value, the microcell stays on working (on) state. Alternating microcells on working (on) and off states, we can save electrical energy.

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In Section 2, we recall related works in this area and our contribution. In Section 3, we introduce general scheme and algorithm flow charts of the handoff green Joint Radio Resource Management (JRRM) algorithm that we developed. Besides, the explanation of our algorithm and it is shown the differences between green JRRM algorithm and handoff JRRM algorithm. Section 4 presents the modelling of our proposed scheme and the state transition diagram to compute blocking probability and idle state probability. Section 5 demonstrates the numerical results of energy-saving. One of them compares the two algorithms based on active microcell numbers. If we compare the number of active microcells, we will find the energy-saving ratio. In the last section, we talk about the future work to bring closer our experimented results to real ones by using real traffic and more microcells.

II. RELATED WORK

Falowo et al. [6] proposed the issue of unbalance in radio resources allocation among limited-capability heterogeneous mobile terminals in HetNets. They reproduced a terminal-modality based joint call admission control method that uses the RAT terminal capability and the network load as criteria for call admission control decisions.

Ngo et al. [7] addressed distributed RRM-based methods to optimally separate subcarriers and power in OFDM-based cognitive radio ad hoc networks. The issue of RRM is formulated as an optimization issue where the throughput is maximized subject to some network-related constraints such as the number of sub channels that each individual unlicensed user might engage, bearable interface at main network level, etc.

Guerrero-Ibanez [8] addressed a QoS-based dynamic pricing approach for services and besides resource supplying in HetNets. In their suggested scheme, an access network selection mechanism is proposed that assists choice the convenient network for every requested user's service and preferences.

Carvalho et al. [9] have proposed to build a green DCM algorithm which is based on a threshold. There are 2 layers which are called macrocell and microcell. Macrocell has the threshold making a decision whether or not microcell is needed to keep off.

In this study, the purpose of DCM algorithm is to ensure the energy efficient through the opening and closing of microcells on system by using a Markov model. Our contribution to this work is to reduce energy consumption by using handoff on macrocell and open the most engaged microcell.

Yao et al. [10] addressed the effectiveness of the derived centralized and decentralized QC-learning algorithms in balancing the tradeoff between energy saving and QoS satisfaction.

III. HANDOFF GREEN JRRM DESIGN

Our green JRRM algorithm is based on the following idea. We have to take into consideration the traffic load fluctuating during the day. The data is used as input values. Load of BSs is used to make a decision about the defining the threshold. The power-saving will be obtained by this threshold.

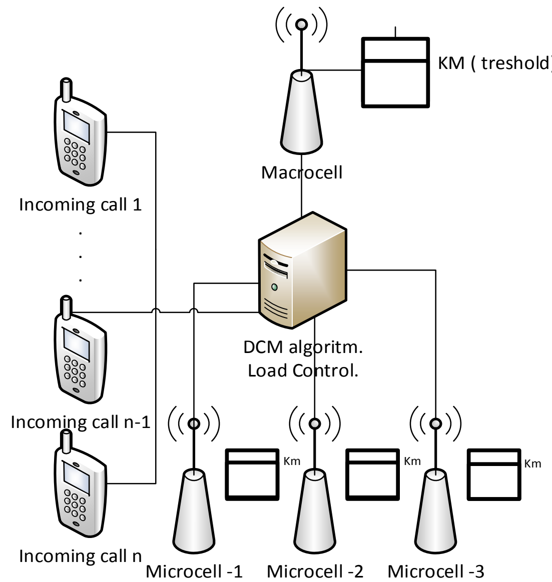

Figure 1 Handoff Green JRRM design

Figure 1 represents our green JRRM algorithm. It has two layers. One of them is called macrocell and the other is called as microcell. K is our Threshold value. According to K value, we are going to make a decision whether a BS is needed to be kept off or not. Load Control (LC) monitors the load of the system by certain periods. The decision of turning off a BS is made by DCM algorithm. In this architecture, macrocell always needs to be kept open. macrocell covers huge geographic territory generally considered as a country. Macrocell and microcells are completely independent of each other.

Figure 2 shows the flowchart of our algorithm. Let I_M be the call number of macrocell, let I_m be the call number of microcell and R_m is the number of calls continuing on microcell. After the calling reached to Green JRRM, it is necessary to determine their source, which requires recognizing whether or not the incoming calls are coming from the macrocell. After the call has been assigned as macrocell, and it is checked if this macrocell has the available capacity to handle the call, then if yes, the call will be accepted by the macrocell. However, if the capacity of the macrocell is full, the incoming call will be dropped. If the incoming call is defined as microcell call, then it is necessary to determine which microcell it belongs to. After the microcell is found, its density variable is increased by 1. All of the density variables of microcells are stored in the array. If they are less than the threshold value, the incoming calls will be handled by the macrocell. The microcells will continue to stay in off. Energy savings will be achieved as long as the microcells are kept off. If the value is greater than threshold (K) value or equal to K value, the most engaged microcell passes into an active position and accepts the call. At this point, the microcell is active, which means that it is consuming energy. The microcell has its own threshold as well. DCM algorithm makes a decision by the assist of its own threshold value whether or not the microcell needs to keep itself off. If incoming calls are equal to the threshold value of the macrocell, or more than the threshold value of the microcell, then the microcell will remain active. If incoming calls are less than the threshold value of the microcell, then the microcell will ask about the intensity of the macrocell. If the intensity of macrocell less than the sum of I_M and R_m calls, the microcell passed to off position itself and R_m calls will be transferred to the macrocell. If macrocell is not available the microcell will stay active. In this way, Energy-efficiency and system balance is assured.

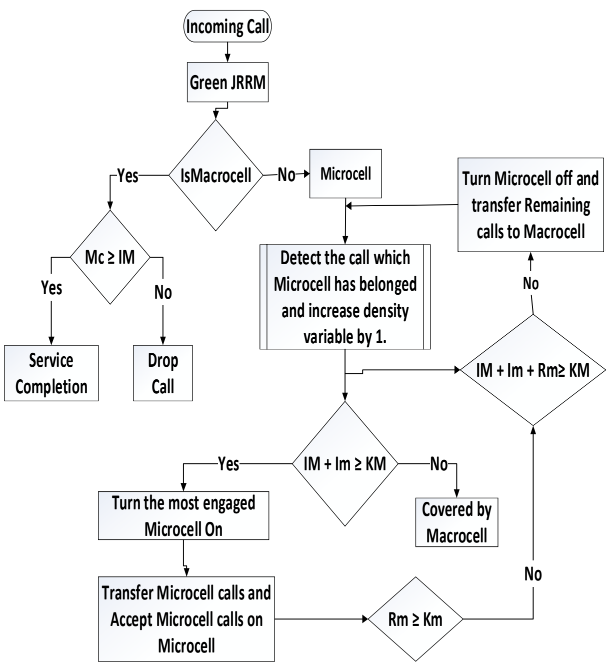

Figure 2 Handoff DCM-based green JRRM algorithm.

IV. PERFORMANCE MODEL FOR HANDOFF

As we mentioned earlier, our model has 2 layers: macrocell and microcell. Arrival process are assumed to be Poisson in both layers with λ_M macrocell rate and λ_m microcell rate. In the green JRRM scheme, the state transition diagram for a small-scale system with M_{cell} =5, m_{cell} = 5, K=2. The number of macrocell and microcell channels are M_{cell} and m_{cell} respectively. K is considered as a threshold value defined by multiplying the capacity of macrocell by a certain coefficient, shown in Figure 3.

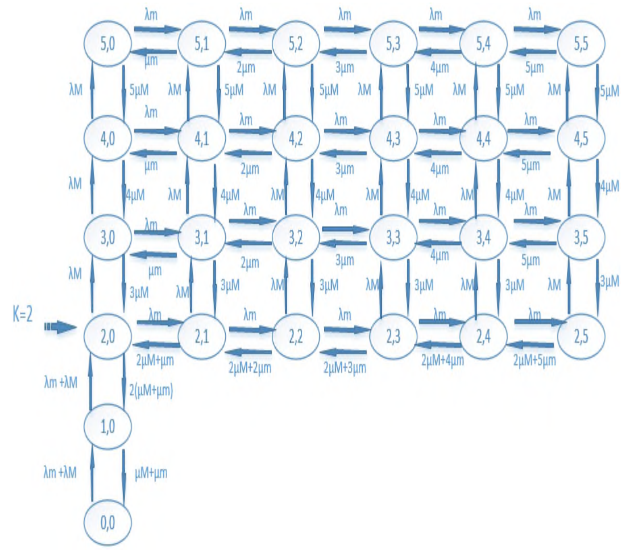

Figure 3 State transition diagram for the handoff green JRRM scheme with M_{cell} = 5, m_{cell} =5, K=2

Figure 3 represents the state diagram threshold value is calculated by multiplying the total capacity of the macrocell by 0.6 (NICIN 0.6) In this case, it is calculated as 3. Using bidimensional Continuous Time Markov Chain (CTMC) model, we define the state as:

$$\boldsymbol{\varphi} = \{(I_M, I_m)\ \mathbf{0} \le I_M \le M_{channel}\ , \mathbf{0} \le I_m \le m_{channel}\ \}$$

From this point, formula 1, the blocking probability in the macrocell and formula 2, the blocking probability in the microcell are obtained as [9]:

$$P_{M_{blocking}} = \sum_{I_m=0}^{m_{channel}} \pi(I_M = M_{channel}, I_m)\ (1)$$

$$P_{m_{blocking}} = \sum_{I_M=0}^{M_{channel}} \pi(I_M,\ I_m = m_{channel}\ )\ (2)$$

Regarding DCM algorithm, formula 3, the probability of idle state of macrocell can be calculated as [9]:

$$P_{idle} = \sum_{I_M=0}^{M_{channel}} \pi(I_M, I_m = 0)\ (3)$$

V. PERFORMANCE EVALUATION

In this section, we evaluate the performance of our DCM-based green JRRM scheme. The scenario of this experiment consists of 1 macrocell and 5 microcells and there is no any macrocell call to measure the performance of microcell call. We assume that the number of channels of the macrocell is 20, and the number of channels of the microcells is 10. The threshold value is 10. The threshold value is automatically determined so that the number of the macrocell's capacity is multiplied by 0.5 coefficients.

Scenario

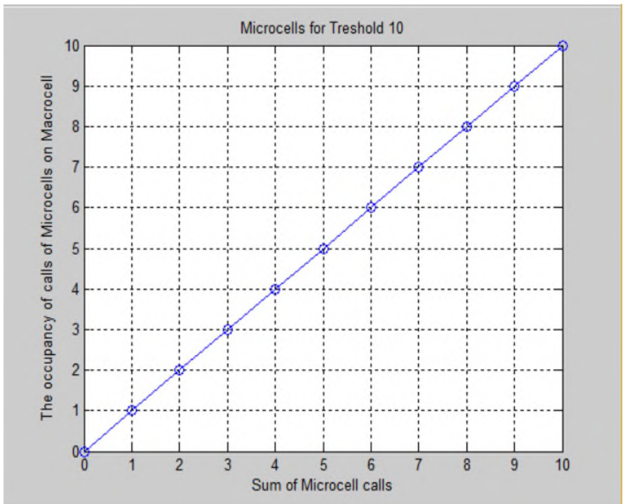

Figure 4 The occupancy of microcell calls on macrocell.

Figure 4 shows the sum of the number of incoming microcell calls. The number of incoming calls can't exceed the value of 10 due to fixing the threshold value to 10.

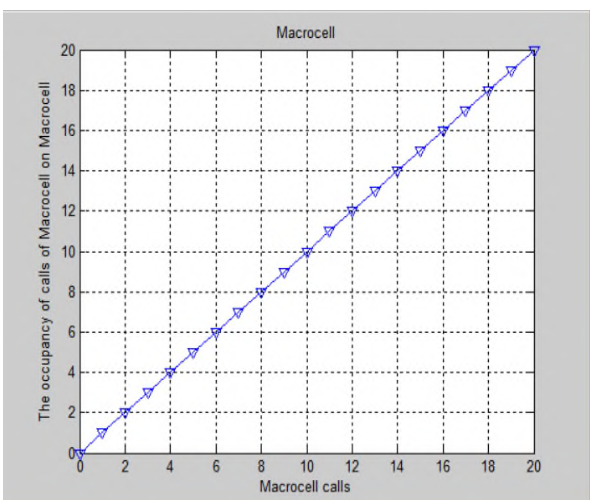

Figure 5 The occupancy of macrocell calls on macrocell.

Figure 5 shows the occupancy of macrocells which have occurred by the incoming calls on them. If there are not any microcell calls on the macrocell, then the macrocell has the right to consume all of the function of the macrocell's channels in order to recover its calls. The threshold value defined on the macrocell means that the sum of the number of microcell calls cannot exceed the threshold value. In our study, first of all, it is necessary to determine exactly the microcell to which the incoming call belongs. Secondly, the intensity variable of the microcell is increased by 1. When the sum of these calls reaches the threshold value, the most engaged microcell is activated, and the calls of this microcell are transferred to itself. Our aim is to underline the advantage of Handoff Green JRRM Architecture versus Green JRRM Architecture. If the number of incoming calls exceeds the threshold value, then the following incoming calls are diverted directly to microcells and will subsequently activate new microcells. The advantage of our approach is manifested at this point. The macrocell is alleviated after it has opened the most engaged microcell on the macrocell. Moreover, channels are opened for receiving new calls. For example, let us assume that the threshold value is 10 and we have 5 microcells. There are 10 calls. The distribution of these calls would be divided in such a way that there would be 4 calls coming from the first microcell, 3 calls coming from the second microcell, and 3 calls coming from the third microcell in a certain time period. In Green JRRM Architecture's approach, the fourth and fifth microcells will be opened even if there is only one call. In Handoff Green JRRM Architecture's approach, the most engaged microcell is activated and the calls are transferred. The other two microcells are covered by the macrocell until a total of 4 calls are keeping one microcell active. In this way, the green DCM algorithm is achieved. In the approach by Green JRRM Architecture, 2 microcells remain in an activated state. This example states that there is an energy savings of 50 %.

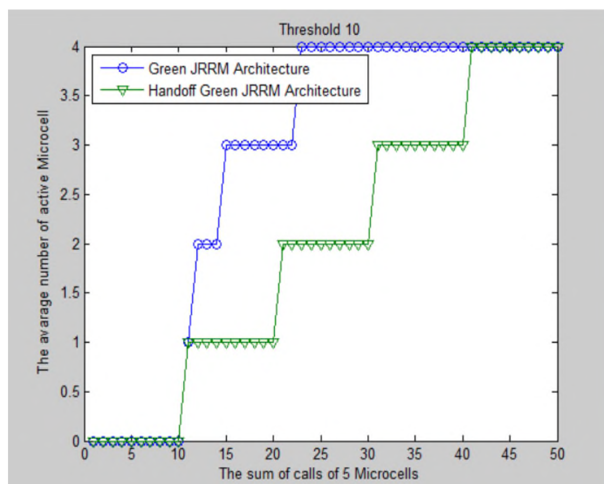

Figure 6 The average number of active microcell.

In Figure 6, the energy saving experiment is demonstrated by 5 microcells as shown above. The maximum number of microcell calls is 10 because of setting the threshold value to 10. As seen in Figure 6., there is a huge difference between the varying approaches made by Green JRRM Architecture and Handoff Green JRRM Architecture. The energy saving activity is made by closing the most engaged microcell. This action leads to alleviating the macrocell. In this way, the calls made by other microcells will continue being accepted on the macrocell.

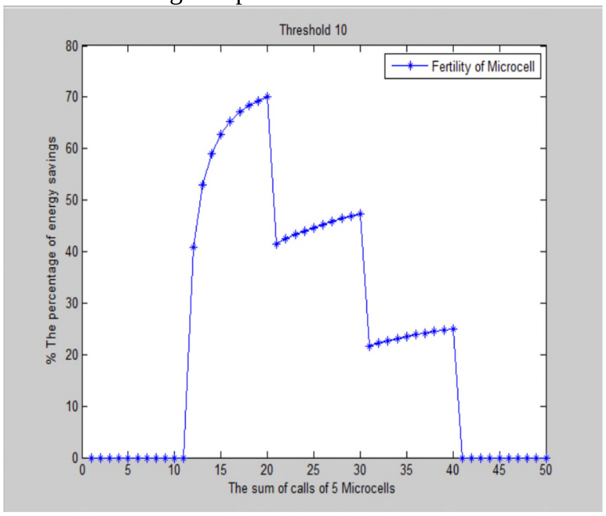

Figure 7 The percentage of energy savings versus Green JRRM Architecture.

In Figure 7, as seen, the energy saving action carried out by 5 microcells is shown as a percentage in Figure 7. It states that until threshold congestion occurs, both approaches act the same. Neither one of these approaches opened a microcell, nor were the calls handled by macrocells. With the average rate of call traffic, energy savings has been recorded in the range of 45% to 70 %. Further energy savings have been achieved by keeping the microcells closed. Energy saving opportunities were diminished by increasing the load of calls.

VI. Conclusion And Future Work

In this paper, we have introduced a new approach to the DCM-based energy efficient scheme for HetNets. Our Handoff DCM algorithm is based on 2 basic structures. One of them uses the Handoff mechanism and the other requires setting a threshold on the macrocell. Using both of these methods, we have obtained more energy savings and developed an anti-pollution algorithm. Green JRRM Architecture diverts new calls directly to the microcell by opening other microcells after the threshold is reached. Handoff Green JRRM Architecture is interesting in the way of opening the most engaged microcell by assigning incoming calls. The results have shown that Handoff Green JRRM Architecture has advantages in all ways, versus Green JRRM Architecture.

In future work, we are going to develop a smarter program by using statistics. We need not only instant data but also a database to assist making a decision which BS needs to open continuously to ensure more energy-efficiency. The next Generation Handoff Green JRRM algorithm will consist of a database and more complex decision mechanism. Further work will include adding more microcells and testing the real traffic load. This will enable us to understand the effect of various traffic loads on our new green DCM algorithm. It will be useful to take some precautions in order to avoid congestion as we strive towards our goal of reaching the pinnacle of energy-efficiency algorithm.

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