SSRG International Journal of Electronics and Communication Engineering Volume 6 Issue 3, 18-22, March 2019
ISSN: 2348 - 8549 / doi:10.14445/23488549/IJECE-V6I3P104

Green Energy Technique for Seven Cell Long Term Evolution (LTE) Cellular Network

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Abstract

This paper introduces an alternative energy-efficient seven-cell cluster of Long Term Evolution (LTE) cellular network. As far as cellular networks are concerned, energy consumption is a significant issue to be minimized. In this paper, we have made a central cell to have maximum transmitted power regarding LTE. The other six cells have the minimum allowed transmitted power in LTE, and they can decide to sleep or not to create an energy-efficient environment and have the concept of load balance. This is based on the number of users in the specific sector. Finally, the result shows that 1.63 % of transmitted power has been saved for the worst case.

Index Terms - *LTE; energy efficiency.*

I. INTRODUCTION

ICT is responsible for 4% of the worldwide primary energy consumption. Radio access networks cause 9% of this ICT consumption. When operating a typical cellular network, such as GSM, WCDMA, or LTE, the base stations normally use around 80% of the energy. Furthermore, within a single base station, the power amplifiers (PAs) are the dominating energy consumers. Typically 80% of the total energy use at a base station site is consumed by the Power amplifiers [2]. Traditionally, mobile terminals have been designed with energy efficiency in mind due to their battery limitations. Besides, core network nodes are, in absolute terms, only marginal consumers, simply because the base stations outnumber them.

Usually, for a cellular network in the urban area during the daytime, the traffic load is comparatively heavy in workplaces and light in residential areas, and it is just the reverse during the dusk. If the network capacities are specified pertaining to the peak traffic volume of every cell, load distribution has not been appropriate, i.e., there are always some traffic load imbalances. Specific cells are under lighter load, and some are heavily loaded. Because of these static cell deployments, there could not be an optimum solution as traffic loads experience fluctuation [6].

Among previous work on energy saving by BS operation management mechanisms, the authors of [5] proposed turning off half of the BSs in a regular pattern and analyzed the call blocking probability and the active cell's average number. A practical implementable switching –on/off based on an energy-saving (SWES) algorithm operated in a distributed manner with low computational complexity has been proposed in [7]. The article in [8] provides an overview of the design and optimization of green energy enabled mobile networks, discusses the energy models for the analysis and optimization of the networks, and lays out basic design principles and research challenges on optimizing the green energy powered mobile networks.
The works mentioned above have not conducted multi-cell energy efficiency for LTE based on cell zooming, sectoring, and sleeping algorithm together. In this particular work, all mentioned gaps have been considered to alleviate the problems

Improved quality of service and making the cellular network green are an important issue affecting the telecom industry. Reducing electrical energy consumption is not the only matter of being green; it is also an economically important issue.

In this paper, we, therefore, focus on reducing energy consumption for six sectored LTE eNBs without affecting the quality of services. We have modeled a system and developed the best-suited algorithm to overcome the problem mentioned above.

The rest of the paper is organized as follows. Section II introduces a system model and explains problem formulation. Section III discusses the proposed algorithm. In section IV, simulation results are presented. Finally, section V holds a brief conclusion about the simulation results.

I. SYSTEM DESCRIPTION AND PROBLEM FORMULATION

A. System Model

System model and associated assumptions used in this paper are summarized below:

- The Channel model is Okumura-Hata, which is the most widely used model in radio frequency propagation for predicting the behavior of cellular transmissions in city outskirts and other rural areas [9], [10]. For this specific work, we have considered the urban environment.

$$PL_{urban} = 69.55 + 26.16\log(f_c) - 13.82\log(h_{tx}) - a(h_{rx}) + (44.9 - 6.55\log(h_t))\log(d) \quad --(1)$$

Where, f_c is the carrier frequency, h_{tx} is transmitter height, h_{rx} is receiver height, d is the distance between a user and eNB and $a(h_{rx})$ is the correction factor for mobile antenna height.

- Cells are deployed in uniform hexagons for seven eNodBs, denoted by eNB1, eNB2, eNB3, eNB4, eNB5, eNB6 and eNB7, lies in the two dimensional area. Our focus is on downlink communication as that is a primary usage mode for the mobile Internet, i.e., from BSs to user equipment (UEs). The central cell(eNB1) is big, and its coverage is indicated by red color, and the other six-cell has equal size as shown in Fig.1

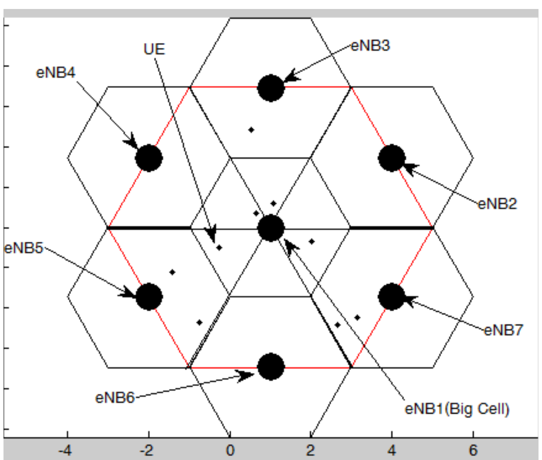

Fig.1. System Model

B. Problem Formulation

In this paper, we aim at proposing an algorithm that minimizes the total energy expenditure by making a self-organizing network having seven eNBs, and the central eNB (eNB1) has high power. The other six eNBs (eNB2, eNB3, eNB4, eNB5, eNB6, and eNB7) help the high power eNB based on the number of users, and the problem is formulated as follows.

$$PT_h = \sum_{S_h=0}^{6} PS_h \quad (2)$$

$$PT_l = \sum_{e=1}^{6}\sum_{S_l=0}^{6} PS_l \quad (3)$$

$$PT_{total} = PT_h + PT_l \quad (4)$$

$$PT_{reduced} = \left(\sum_{S_h=1}^{n} S_{active,h}\right) xPS_h + \left(\sum_{e=1}^{6}\sum_{S_l=1}^{n} S_{active,l}\right) xPS_l \quad (5)$$

$$PT_{saved} = PT_{total} - PT_{reduced} \quad (6)$$

Where, PT_h , PT_l are the transmitted power of high power cell and less power cell, respectively.
PS_h, PS_l are power given to each sector of high power and less power cell respectively.
PT_{total} is the total power in the network
$PT_{reduced}$ is reduced power by the algorithm
$S_{active,h}$ is the indicator function of the number of the active sector in the high power cell $S_{active,l}$ is the indicator function of number active sector in less power cell

II. THE PROPOSED ALGORITHM

In non-energy efficient LTE, eNBs are typically deployed based on peak traffic volume and stay turned-on irrespective of traffic load; it is possible to save huge energy by:

- ✓ Sleeping the three sectors of eNB2, eNB3, eNB4, eNB5, eNB6, and eNB7, then replacing these sectors' service by sector 1, sector 2, sector 3, sector 4, sector 5, and sector 6 of the high power cell respectively.
- ✓ Sleeping underutilized sector in each cell

A. Zooming Algorithms

We have written a pseudo code, as shown in **algorithm 1** below, by fixing threshold one(thr1) for the number of users in the central cell. This is accomplished by counting the number of users in six sectors of eNB1 and make a decision accordingly. Therefore, the pilot power of eNB1 for each sector (P of eNB1_Si) is maximum power when the number of a user is less than thr1. Unless the sector, where the number of users exceeded thr1, must be zoom in and allow the respective cell to provide service in that area. The user out of the central cell is input to the decision taken by eNBj, which is forcing the sector to sleep or active, according to threshold two(thr2). **Algorithm 2** depicts that how to perform load balance when the number of users exceeded the capacity of the central cell. Half of the radius of the specific sector of the central cell, where the number of a user is greater than thr1, must be reduced to make a zoom in.

Algorithm 1 general algorithm

```
Initialize i=1,j=2 and thr1;
Count the NU in Si;
Count the number of eNBj;
for i=1 to 6 do

    if NU<thr1 then
        P of eNB1_Si =Pmax;
        Perform eNBj
P_allocation2;
    else
        Perform eNB1 P_allocation1;
        Perform eNBj P_allocation2;
    end if
end for
```

Algorithm 2 eNB1 P_allocation1

```
Initialize i=1, j=2 and thr1;
Count the NU in Si;
Count the number of eNBj;
for i=1 to 6 do

    ifNU<thr1 then

        P of eNB1=Pmax;
        Perform eNBj P_allocation2;
    else
        R1 of Si=0.5 x R1;
        P of Si of eNB1=Ph min;
        Perform eNBj P_allocation2;

    end if
end for
```

B. Sleeping Algorithms

Central cell power allocation two (eNB1 P_allocation2) is performed based on thr2. When the number of a user is very small or zero, the sector should not radiate its power; rather, it must sleep. **Algorithm3** shows the pseudo-code capable of doing this. Similarly, **Algorithm 4** belongs to the other six cells. However, in this case, we can have two types of sectors. The one inserted into the big central cell (eNB1) and they are three in number. Second, outside sectors (OS), which are three in number, but they are out of the coverage of eNB1.

Algorithm 3 eNB1 P_allocation2

```
Initialize i=1, j=2 and thr2;
Count the NU in Si;

for i=1 to 6 do

    if NU<thr2 then
        Sleep Si of eNB1;
    else
        Perform eNB1
P_allocation1;
    end if
end for
```

Algorithm 4eNBj P_allocation2

```
Initialize i=1, j=2 and thr2;
Count the NU in OSi of eNBj;

for i=1 to 6 do

    if NU<thr2 then
        Sleep OSi of eNBj;

    else
        Perform eNB1
P_allocation1;
        P of OSi of eNBj=Pl max;

    end if
end for
```

Where OS are sectors of eNBj that are out of eNB1.

III. SIMULATION RESULT

The assumption for this simulation

- ✓ When the sectors of each eNodBs changing their color to black, they are in the sleeping mode
- ✓ When the sectors of the high power cell changing their color to green, they are zooming in and allow the closer eNodB to give service to the user in that area.
- ✓ Small black dots represent mobile users
- ✓ Bold black dots represent eNBs

Scenario One

- ✓ The cooperation of central eNB (eNB1) with the other eNBs.

Case I.

- ✓ The occurrence of load balancing

When the number of a user is greater than the capacity of sectors of central eNB (eNB1), the decision has been made to activate the three sectors of the corresponding eNBs. Furthermore, the user has served by both eNBs (eNB1 and corresponding eNB for sectors of eNB1) as shown in fig2.

Case II:

In this case, the number of users in sector 1 of eNB1 is less than the threshold one (THR1) and greater than threshold two (THR2). At this time sector, 1 of eNB1 can give service without the need of three sectors of eNB2.

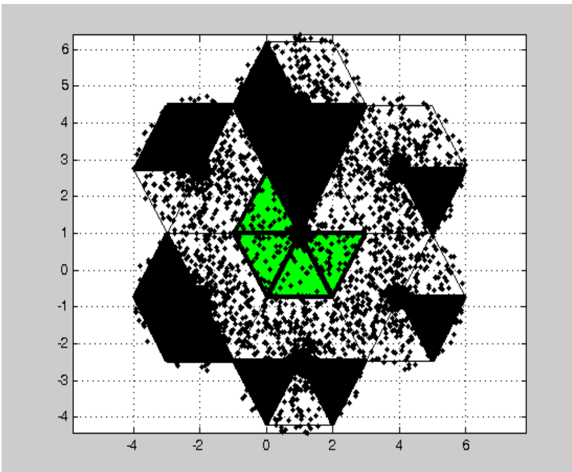

Fig .2.Scenario One

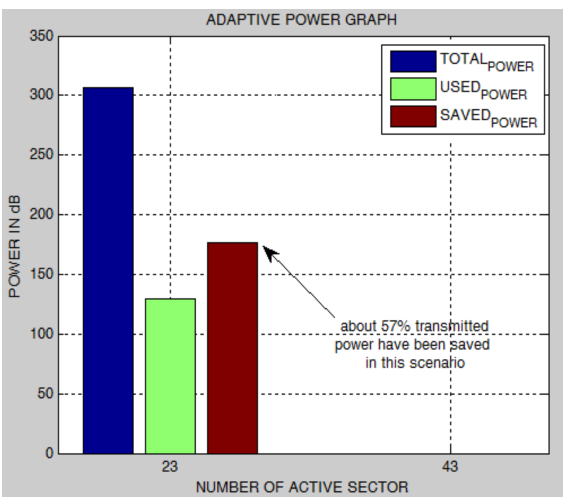

Fig.3. Saved Power for Scenario One

Scenario Two

In this scenario the fig 4 shows that the whole sector of the eNodB1 and three sectors of eNodB2, eNodB3, eNodB4, eNodB5, eNodB6 and eNodB7 are in active mode. This is because of a huge number of users, which is greater than that of threshold two, as described in section II.

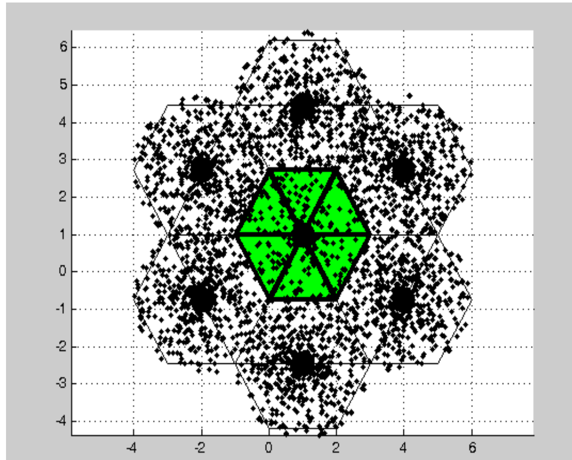

Fig.4. the Whole Sector Active

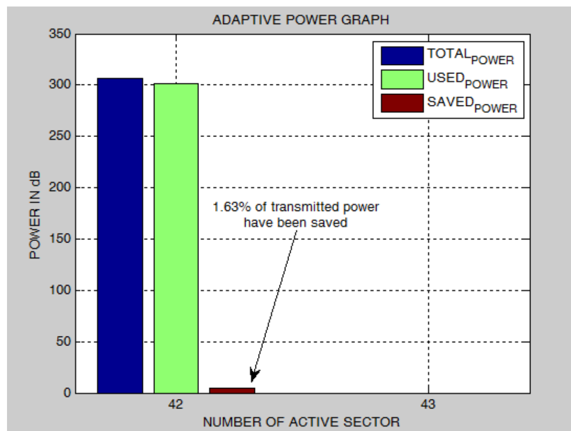

Fig .5.Saved Power for Scenario Two

Scenario Three

In this scenario the whole sector of the eNodB1, eNodB2, eNodB3, eNodB4, eNodB5, eNodB6 and eNodB7 are in sleep mode even it is not happening in real world. This is because of extremely small number of user which is less than that of threshold two as described in section II.

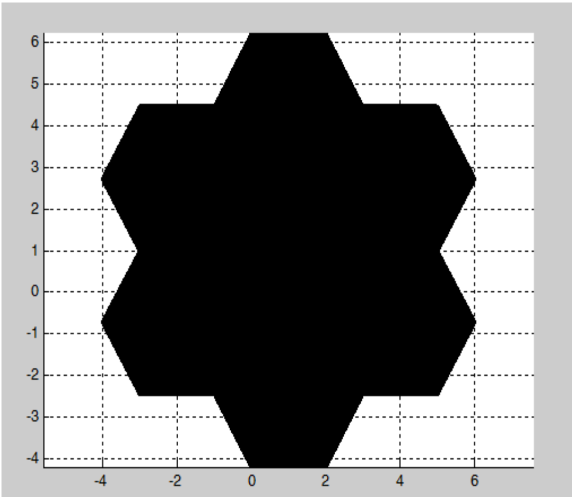

Fig.6. the Whole Sectors sleep During off Peak Hour

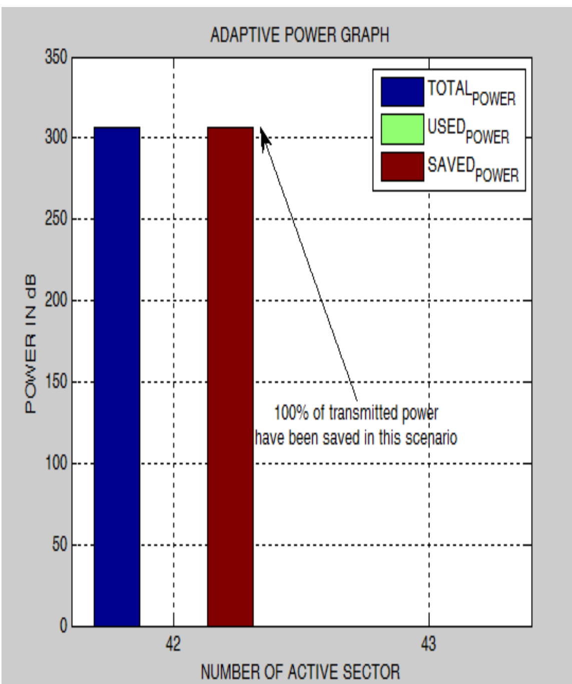

Fig .7 Saved Power for Scenario Three

IV. CONCLUSION

This paper is based on LTE cellular networks. During this research work, an energy-efficient model for LTE has been developed. The transmission of power efficiency has been modeled. However, research on the green cellular network is quite broad; this paperwork on seven cell clustering transmitted power efficiency as effective ways to improve energy efficiency. This, on the other hand, will minimize the power consumption of power amplifiers and other circuits.

The result shows that the minimum transmitted power that has been saved in this research is 1.63%. This is the worst-case scenario when all sectors of three eNBs are active. This is obtained through the technique discussed in this paper, and it is essential for operating expense(OPEX) cost reduction for the mobile network operators.

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