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# Green Energy Based Long Term Evolution (LTE) Radio Network Planning for the Case of Semera City

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***Abstract:***
*This paper presents an energy efficient Long Term Evolution (LTE) dimensioning and performs a case study in Semera with 35 square kilo meter area. Improved quality of service, cost reduction and making the cellular network green has become the most compelling challenge for researcher and they are important issue affecting the telecom industry. In this paper, the existing five base stations of 3G network has been reduced to three eNodeBs (eNBs) and properly placed as to improve the coverage area. A survey on different sources of energy has been conducted. Finally, an algorithm has been modeled and simulated which has capable of making the network environmental friendly. The proposed algorithm has saved minimum of 1.25% of transmitted power while satisfying quality of service.*

***Keywords:*** *LTE dimensioning, energy efficiency*

## 1. Introduction

Usually for a cellular network in the urban at daytime the traffic load is comparatively heavy in workplaces and light in housing areas and it is just the conflicting during the dusk. If the network capacities are specified pertaining to the peak traffic volume of every cells, load distribution will not be appropriate i.e., there are always some traffic load imbalances. Specific cells are under lighter load and some are heavy loaded. Because of this static cell deployments couldn't be an optimum solution as traffic loads experiences fluctuation [1].

ICT is responsible for 4% of the worldwide primary energy consumption. 9% of this ICT consumption is caused by radio access networks. When operating a typical cellular network, such as GSM, WCDMA, or LTE, around 80% of the energy is normally used by the base stations. Traditionally, the mobile terminals have been designed with energy efficiency in mind due to their battery limitations. In addition, core network nodes are in absolute terms only marginal consumers, simply because they are outnumbered by the base stations. 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]. These numbers indicate that the power consumption of wireless access networks is going to become an important issue in the next few years. To model and optimize the power consumption in those networks, the focus should therefore be on the base stations [3].

In this paper the reduction of energy consumption for LTE eNBs has been modeled for the new radio network planning of Semera by making the transmitted power much more efficient.

## 2. Energy Efficient LTE Network Planning

### *2.1. Nominal Planning for Semera City*

Semera is the capital of Afar region in Ethiopia. Efficient radio network planning is obviously a big challenge here with the optimal utilization of limited resources. In this part of the work, coverage analysis and link budget preparation along with modeling the system, formulating the problem and proposing suitable algorithm has been analyzed. Calculations have been made Semera city specific.

## 3. Energy Efficient System Description and Problem Formulation

### *3.1. System Model*

We consider a wireless cellular network where three eNodBs, denoted by eNB1, eNB2 and eNB3, 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 equipments (UEs).

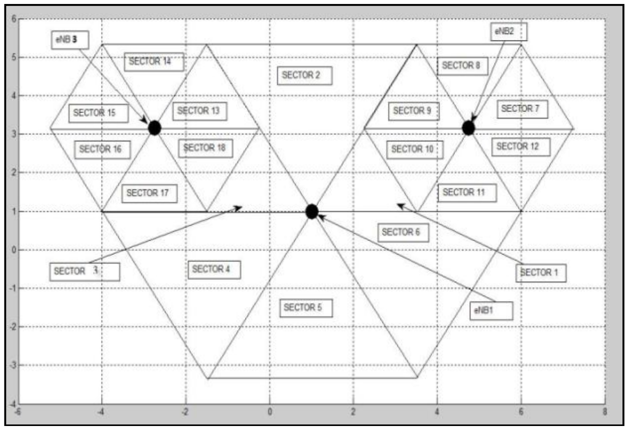

*Figure 1: System Model*

### *3.2. General Problem Formulation*

In this paper, we aim at proposing algorithm that minimizes the total energy expenditure by making a self organizing network having three eNBs and one of eNB has high power. The other two eNBs (eNB1 and eNB2) help the high power eNB based on traffic density. Our objective function is given by

$$PT_h = \sum_{S_h=0}^{6} \mathrm{PS_h} \qquad (1)$$

$$\mathrm{PT_l} = \sum_{e=1}^{2} \sum_{S_l=0}^{6} \mathrm{PS_l} \qquad (2)$$

$$PT_{total} = PT_h + PT_l \qquad (3)$$

$$PT_{reduced} = \left( \sum_{S_h=1}^{n} S_{active,h} \right) xPS_h + \left( \sum_{e=1}^{2} \sum_{S_l=1}^{n} S_{active,l} \right) xPS_l \qquad (4)$$

$$PT_{saved} = PT_{total} - PT_{reduced} \qquad (5)$$

Where, $PT_h$ , $\mathrm{PT_l}$ are the transmitted power of high power cell and less power cell respectively.

$\mathrm{PS_h}$, $\mathrm{PS_l}$ 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 indication function of number of active sector in high power cell $S_{active,l}$ is the indication function of number active sector in less power cell

### *3.3. The Proposed Algorithm*

In non-energy efficient LTE planning eNBs are typically deployed on the basis of 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 and three sectors eNB3 and replacing the service of these sectors by sector one and sector three of the high power cell respectively.
- Sleeping underutilized sector in each cell

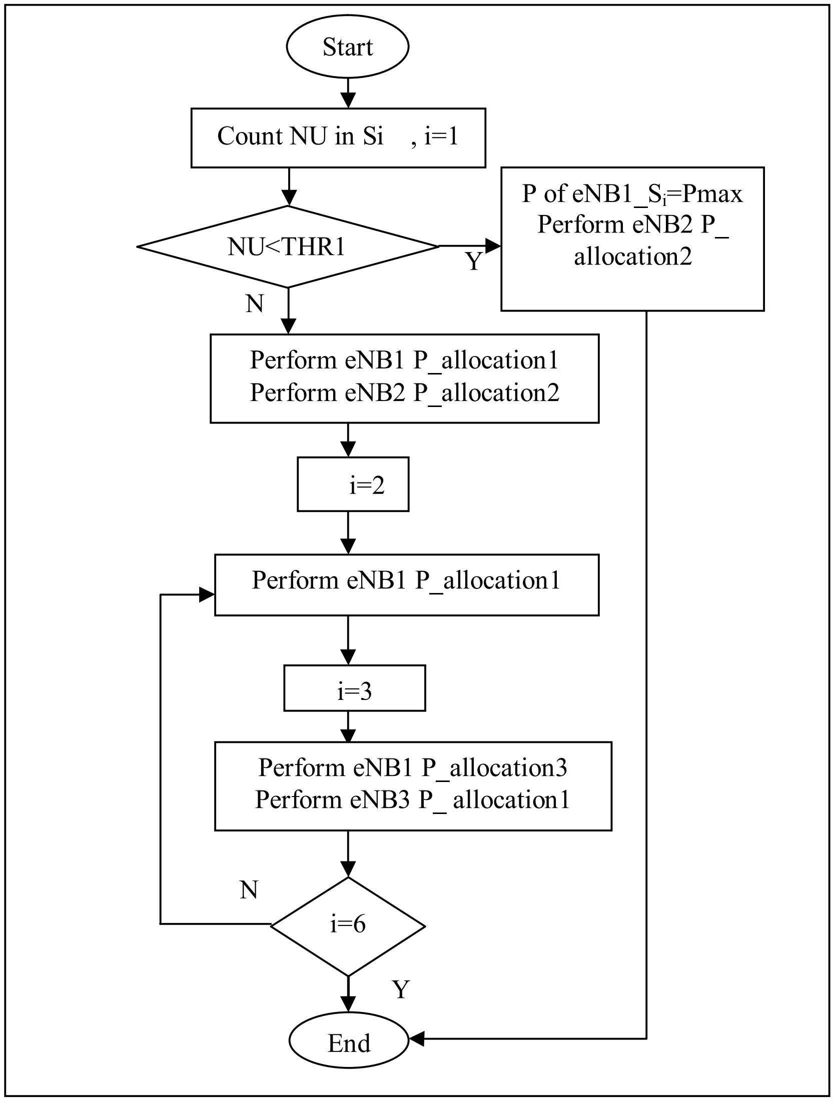


*Figure 2: Flow Chart of the Proposed Algorithm*

Where,
*NU* is the number of user in each sector
$S_i$ is the name of the sector in eNB1 i.e $S_1$, $S_2$, $S_3$, ---$S_6$
*THR1* is the threshold value by which the decision is made whether allocating maximum power in that specific sector (sector 1 and sector 3 of eNB1) or allocating the minimum power by looking at *THR2*.
Perform eNB1 P_allocation1 is power allocation of eNB1 where number of user in sector one is less than THR1and sector one is capable of giving service to the user over there.
Perform eNB2 P_allocation2 is power allocation of eNB2 where the sector of eNB2 that are not inserted in to eNB1 can be managed.
Perform eNB1 P_allocation3 is power allocation of eNB1 and at this time the power allocation of sector three can be managed.
Perform eNB3 P_ allocation1is power allocation of eNB3 and at this time the sector of eNB3 that are not inserted in to eNB1 can be managed.

*3.4. Algorithm Description*
1) Sleeping sector 9, 10 and 11: The decision criterion is based on the number of user in sector1.
By counting the mobile station in sector 1 the high power eNB (eNB1) will decides

- Giving service to user or
- Ignoring the user
- Sharing the user with eNB2

If the number of user is extremely small (less than threshold two) or if the user in that area can be served by central eNB (less than threshold one), automatically the above mentioned three sectors of eNB2 will be sleeping.
2) Sleeping sector 13, 17 and 18 of eNB3: The decision criterion is based on the number of user in sector3.
By counting the mobile station in sector 1 the high power eNB will decide three things

- Give service to user
- Ignoring user
- Sharing the user with eNB3

If the number of user is extremely small (less than threshold two) or if the user in that area can be served by central eNB (less than threshold one), automatically sector 1,5 and 6 of eNB3 will be sleeping and replaced by sector 3 of the high power cell.
3) Sleep the sectors in central eNB: The decision criterion is based on the number of user in respective sector.
By counting the mobile station in sector 2, 4, 5 and 6 the central eNB will decides

- Give service to user
- Ignoring user

If the number of user is extremely small (less than threshold two), the user will be ignored and the specific sector will be sleep otherwise the user can be served by the specific sector
From the very beginning we have collected area information and decided the propagation model. Then we proceeded to calculate the radio link budget (RLB) design. The uplink and downlink cell radius can be calculated based on the RLB analysis after selecting propagation model. Effective cell radius is the minimum among uplink and downlink maximum allowable path loss (MAPL). After this stage the number of site are determined and it is significant for coverage estimation.

**4. Dimensioning**

In this section based on the above link budget calculation and equation 4.1, the number of eNBs has been calculated as follows.
Area of Semera= 35km$^2$
Cell range=2.155 km (Considering Semera as Suburban)
Area of single cell = 2.6 x (cell range)$^2$
=2.6 x 2.130$^2$
=11.7959km$^2$
Number of eNodB= Area of Computational Zone / Area of the cell
= 35km$^2$ / 12.074 km$^2$
=2.96
That means we need three eNodBs

| | uplink |
|---|---|
| transmitter –UE | |
| Tx power(dBm) | 23 |
| Tx antenna gain(dBi) | 0 |
| Tx loss (Body loss(dB)) | 0 |
| EIRP(dBm) | 23 |
| Receiver-NodeB | |
| eNodeB noise figure(dB) | 2 |
| Thermal noise(dB) | -118.4 |
| Receiver noise(dBm) | -116.4 |
| SINR(dB) | -7 |
| Receiver sensitivity(dB) | -123.4 |
| Interference margin(dB) | 1 |
| Cable loss(dB) | 0 |
| Rx antenna gain(dBi) | 18 |
| Shadowing loss(dB) | 7 |
| Indoor penetration loss(dB) | 20 |
| Maximum path loss(dB) | 136.4 |

*Table 1: Link Budget Calculations*

| | | Unit |
|---|---|---|
| Carrier frequency | 2100 | MHz |
| BS antenna height | 25 | M |
| MS antenna height | 1.5 | M |
| Environment | 1 | |
| MS antenna gain function (large city) | -0.00092 | |
| MS antenna gain function (suburban) | 12.48071 | |
| Path loss exponent | 35.74349 | |
| Path loss constant (large city) | 137.1406 | dB |
| Path loss constant (small city) | 137.0907 | dB |
| Path loss constant (suburban area) | 124.659 | dB |
| Path loss constant (rural area) | 104.2298 | dB |
| DL Range (large city) | 0.953 | Km |
| DL Range (suburban) | 2.130 | Km |

*Table 2: Parameters for the Okumura-Hata Propagation Model*

Based on the link budget calculation as clearly stated above and table 3 the number of eNBs from five base stations decreased to three eNBs. The location of the first eNB was selected to be on the existing base station around Semera telecommunication office (11.472852N, 41.0344E).Figure 4 depicts the exact location of the sites
The rest two sites have the location as follows:

- eNB2: it is logically located exactly 2.130 km in the north east direction of the central eNB.
- eNB3: this eNB also located exactly 2.130 km to the north west of the central eNB.

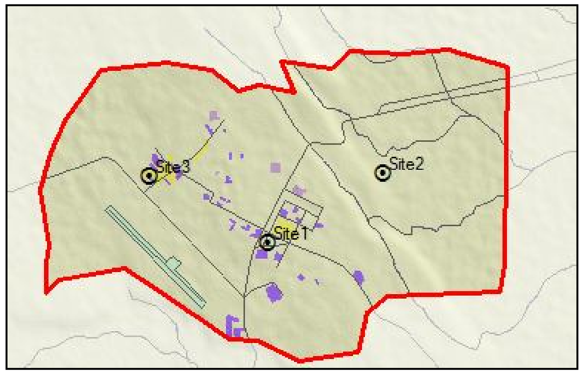

*Figure 3: the Proposed Location of Sites*

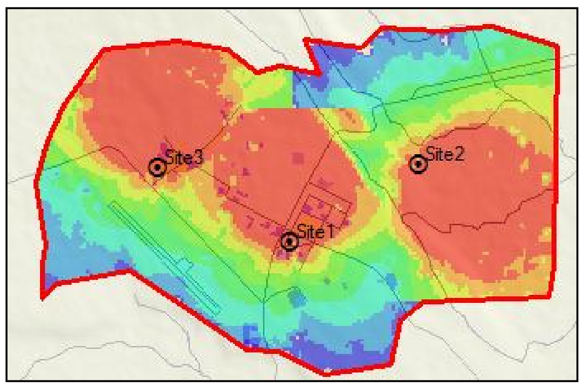

*Figure 4: Coverage by Signal Level*

The coverage is estimated by signal level. The topology tells us that there is no single point in the deployment area that is out of the signal radiated from three eNBs as shown in figure 4. The histogram in figure 5 shows the detail explanation of signal level. The detail planning is the coming stage. Our main question was 'can the new system model cover the whole area of Semera city?' Here what we notice is that the question from the perspective of our objective was successfully answered. So this answer can be our spring board to do the main objective of this thesis work that is energy efficiency. All simulation result related to energy efficiency has been discussed in the coming topic.

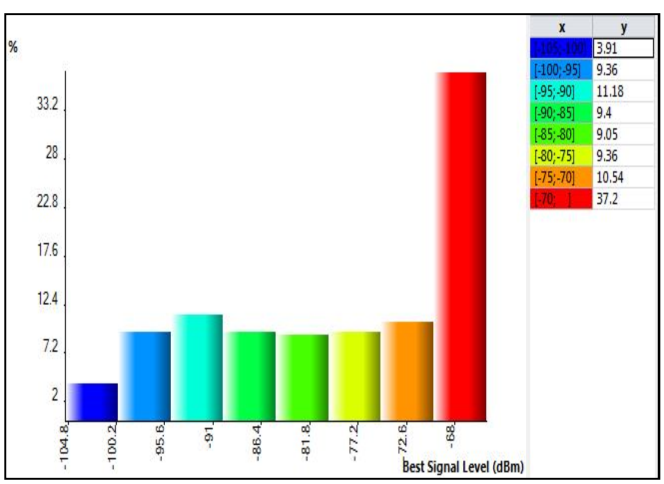

*Figure 5: Signal Level versus Coverage Area in Percent*

**5. Simulation Result on Energy Efficiency**

Assumption for this simulation

- When the sectors of each eNodBs changing their color to black, they are at the sleeping mode
- When sector 1 and sector 3 of the high power cell(eNB1) changing their color to green, they are zooming in and allow the closer eNodB to give service to user in that area.

*5.1. Scenario One*

- The cooperation of central eNB (eNB1) with eNB2 and eNB3.

Case I.

- Occurrence of load balancing in sector 1.

When the number of user is greater than the capacity of sector 1of central eNB (eNB1), the decision has been made to activate the three sectors of eNB2. And the user will have served by both eNBs (eNB1 and eNB2) as shown in figure 6.

Case II:

In this case the number of user in sector 3 of eNB1 is less than threshold one (THR1) and greater than threshold two (THR2). At this time sector 3 is capable of giving service without the need of sector13, sector 17 and sector 18 of eNB3.

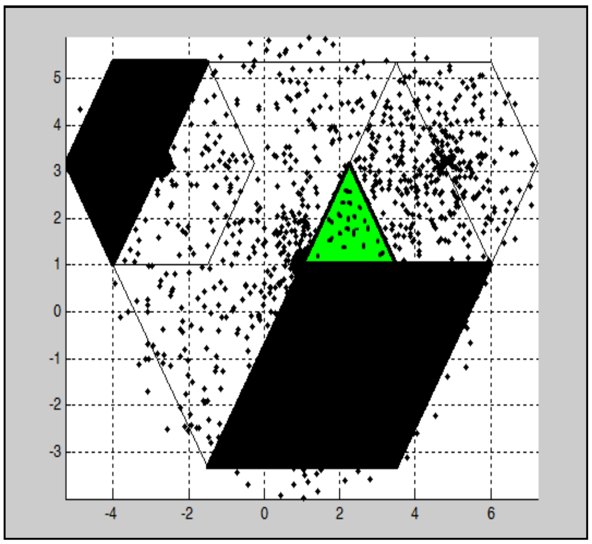

*Figure 6: Scenario One*

Sector 3 of the central eNB is giving service to the whole user in that area. At this moment the capacity of sector 3 of central eNB is capable of giving service.

*5.2. Scenario Two*

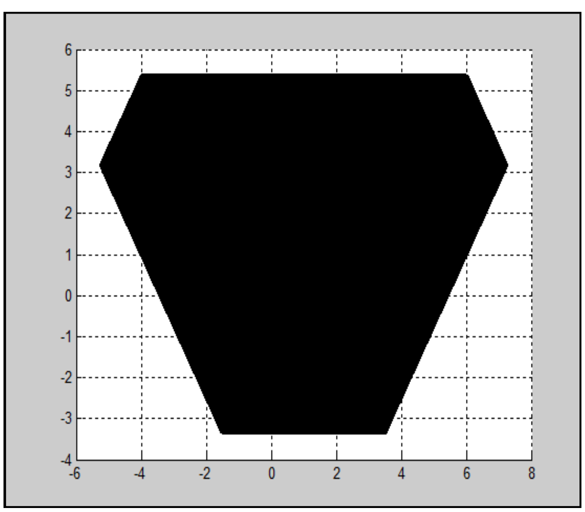

*Figure 7: the whole Sector Sleep during off Peak Hour*

In this scenario the whole sector of the eNodB1, eNodB2 and eNodB3 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 above.

*5.3. Scenario Three*

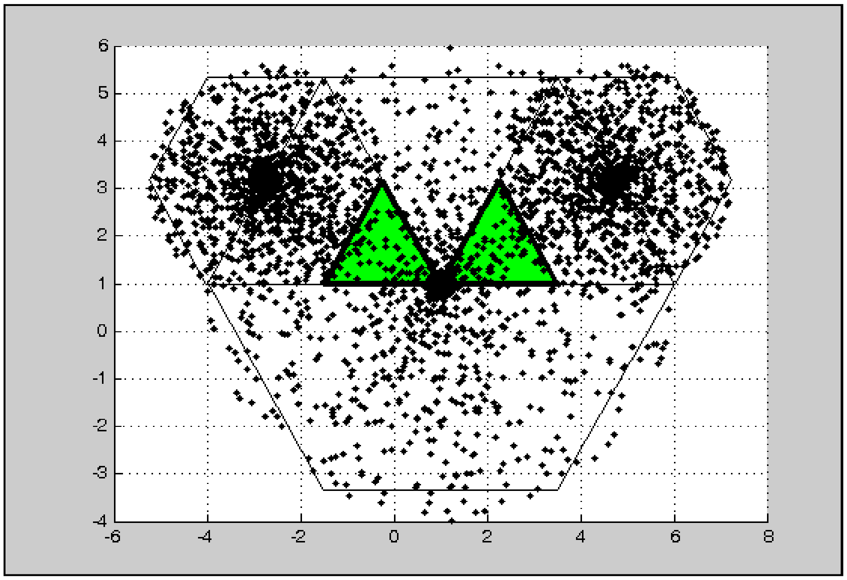


*Figure 8: the whole Sector Active*

In this scenario the graph emphasize that the whole sector of the eNodB1 and three sector of eNodB2 and three sector of eNodB3 are in active mode. This is because of huge number of user which is greater than that of threshold two as described above.

5.3.1. Power Graph

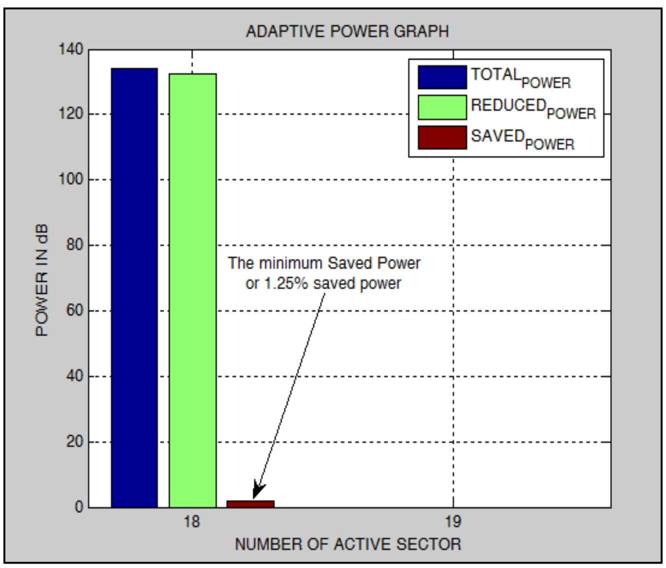


*Figure 9: Power versus Number of Active Sector*

By taking sample scenario we have calculated the transmitted power necessary to the worst scenario (when all sector active), reduced transmitted power and saved power in dB.

Due to the saved power at the transmitted stage with a given time the energy consumption of the whole eNB will decrease. In our case we have tried to make the transmitted power efficient based on the topology we have proposed for the case of Semera,

- By zooming in two sector of central eNB.
- By making all the other sector of three eNBs sleep due to user density.

**6. Conclusion**

This thesis work is based on the dimensioning of LTE Networks. During the course of this research work energy efficient model for LTE dimensioning has been developed. The proposed dimensioning of LTE for Semera city decreases the existing five GSM and 3G base stations to three eNBs with better coverage and this implies that the decrease in operational cost of the network.

In addition to that the transmission power efficiency has been modeled after conducting the survey on green source of energy. However, research on green cellular network is quite broad; this paper highlighted on some of the source of green energy and work on transmitted power efficiency as effective ways to improve the 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 1.25%. This is the worst case scenario when all sectors of three eNBs are active. this obtained through the technique that are discussed in this paper and it is essential for operating expense(OPEX) cost reduction for the mobile network operators(ethio telecom).

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