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Gratuitous Power Reduction in LTE Networks

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***Abstract*- Long term evolution networks have larger bandwidth as well as larger power consumption for transmission. Dynamic base station switching is reduce the power consumption and that is requires high computational complexity as well as large signaling overhead. We propose a practically implementable switching based energy saving (SES) algorithm that can be operated with low computational complexity. SES algorithm can be operated in a distributed manner and key design principle of this algorithm is to turn of the base station one by one when low traffic period. It will minimally affect the network, by using introduced notion of network impact, the switch off base station users can be handover to neighboring base station. In order to reduce the signaling and implementation overhead the heuristic version of SES can be implemented. In our analysis 50-60% of power consumption can be reduced in metropolitan Area Network.**

Keywords- LTE Network, Dynamic base station, Energy consumption, Green cellular network

I. INTRODUCTION

A. Motivation

Recently mobile phones had exploded by smart phones that offers unique internet access of high power reception and carbon footprint. In particular the whole Information and Communication Technology (ICT) has emitted the 2 percent of global CO2 emission in 2007[4, 5]. It will be being increased double in 2020. Today's some biotic components of eco system was destroyed by wireless high power transmission.

The main aim of this paper is to reduce the power consumption at base stations that can be achieved in many ways such as power amplifiers, coolants, relays (or) microcells BSs. We concentrate on the dynamic base station switching on/off based energy saving, which allows the system to totally shutdown.

We shall start with figure 1 that shows the base station switching on/off strategies. We assume that the LTE network has a many base stations and each base station has the low and high traffic threshold levels. Each base station checks their traffic level at every seconds. If traffic level is less than threshold level the base station can be switched off. Otherwise it won't be switched off.

B. Prior work

Energy efficient design of cellular wireless networks has recently received significant [3, 6-17]. In [10] the authors suggested the possibility of energy saving by dynamic base station operation based BS switching related with the traffic profile. As an extension they studied BS switching strategies based on a simple analytical model [7]. In [1] they focused downlink frequency only and they suggested to consider uplink frequency (OR) uplink as well as downlink frequency. And they suggested to calculate BS of metropolitan, macro, micro BS, from that works this paper focused metropolitan area network. Basic concept of dynamic base station operation issues are summarized in [6, 14] and some algorithms are proposed in [15-17] these algorithms was saving energy significantly. By these algorithms the SWES algorithm was implemented.

II. SYSTEM DESCRIPTION

A. Network model

We assume that the metropolitan area network where set of base stations denoted as B lies in the two dimensional geographical area A. Our focus is on downlink communication i.e., from base station to mobile station.

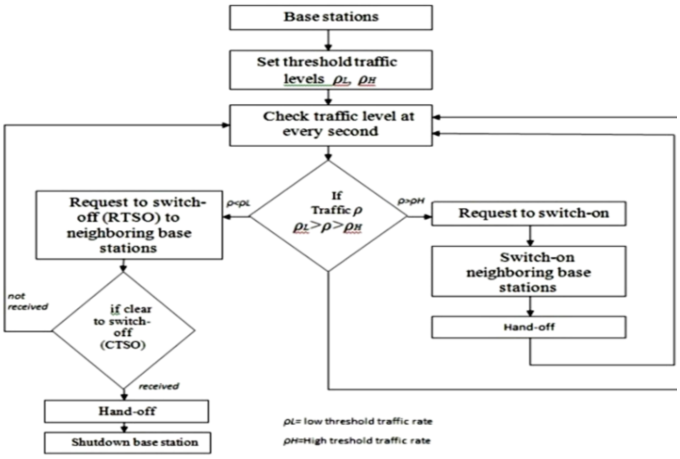

Figure 1: base station switching on/off strategies

B. Traffic model

For our analysis we consider traffic model as a packet based traffic. We imagined the traffic arrival rate of mobile equipment is modeled as an independent Poisson distribution λ(x, t). Its average packet size is modeled as an exponentially distributed random variable 1/μ(x, t). (1) defines the traffic load of mobile equipment.

$$\gamma(x, t) = \lambda(x, t) \;/\; \mu(x, t) \text{ [in bps]}, \quad (1)$$

$\lambda(x, t)$ ⟶ traffic arrival rate of location x, time t

$1/\mu(x, t)$ ⟶ average packet size of location x, time t

C. Channel model

We consider the physical capacity is modeled by Shannon capacity theorem. The service rate of mobile equipment at location x from base station b at time t is calculated as

$$s_b(x, t) = BW \cdot \log_2(1 + SINR_b(x, t)), \quad (2)$$

BW ⟶ Bandwidth

$SINR_b(x, t)$ ⟶ signal to interference ratio at location x from base station b and time t.

$$SINR_b(x,t) = \frac{g(b,x).P_b}{\sum_{i \in ton \to \{b\}} g(i,x).P_i + \sigma^2} \quad (3)$$

$g(b, x)$ ⟶ base station gain

$g(i, x)$ ⟶ mobile equipment gain

P_b ⟶ probability of switch on base station

σ^2 ⟶ noise power

D. Base stations switching strategies

In this paper we concentrate only base station switching algorithm can be expressed as

$$U(a) = \sum_{b \in B} \int_0^T E_{BS}.a_b(t).dt \quad (4)$$

EBS ⟶ power consumption

$ab(t)$ ⟶ Base station activity indicator From (4) we understand that the overall base stations Switching on strategies within 0 to T timing.

III. SES ALGORITHM

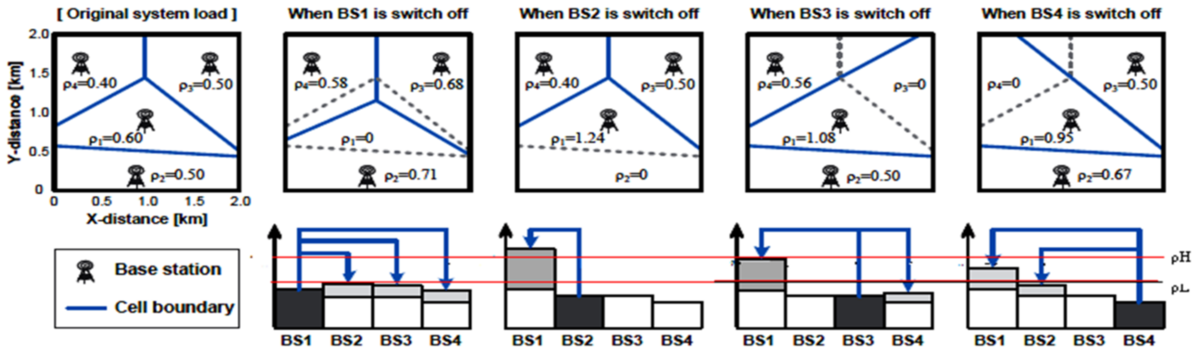

Figure 2: SES algorithm

The main focus of the SES algorithm is to turn off base stations when the traffic level is low. Fig 2 illustrates the model of SES algorithm. We assume that the two dimensional geographical area consist of four base stations. In practically the cells does not splitting in a right shape that is also considered. Then the high and low traffic level of base stations are setted as same value and each base station check their traffic levels. Assume the traffic profile of all base station had low traffic profile. From fig 2 when BS1 is off the BS1 load will be shared with neighboring BSs that is shown. Similarly BS2, BS3 and BS4 when off period the corresponding BSs load will be shared with the corresponding neighboring BSs. But the base stations should not shutdown improperly. It will affect the network totally so we consider some switching on/off procedure[1] as follows:

A. *Switching off algorithm*

From starts with fig 3 shows three states to shutdown the base station had been defined [1].

1. *Pre-processing state*

   In pre-processing state the base stations are exchange their signal strength as well as the system load of base station for calculating their internal as well as external system load.

2. *Decision state*

   Depends upon the request priority base stations are decided to which BS will be turned-off for that decision low traffic profile BSs are send Request To Switching Off (RTSO) to their neighboring BSs. Which BSs get the Clear To Switching OFF(CTSO) from all their neighboring stations that will send the Conformation To Switching Off (CLSO).

3. *Post-processing state*

   Without any CLSO signal the base station should not turned off. After BS turned off the mobile users under switched-off base station is hand-over to neighboring stations.

B. *Switching on algorithm*

1. *Pre-processing state*

   In this state the switched-off base station should be turn on. So depends upon this state is equal to post-processing state of switching off algorithm that is mentioned in figure 3.

2. *Decision state*

   From the base station was switched-off the neighboring stations are check their traffic level at every seconds. When the traffic level crossing the high threshold level base station is decided to turn on switched-off BS. So in this state neighboring base station will send the Request To Switching ON (RTSON).

3. *Post-processing state*

   When RTSON is received from any of one neighboring base station, automatically switched-off BS going to turn on. Appropriate users are hand-over to their primary base stations.

C. *Heuristic versions of SES*

Table 1 shows the heuristic consideration of SES algorithm. In generally we design the SES(1,1) that is considered the internal as well as external traffic also but the heuristic versions won't consider the any one (or) both traffic parameters because of high signaling overhead. And computational complexity

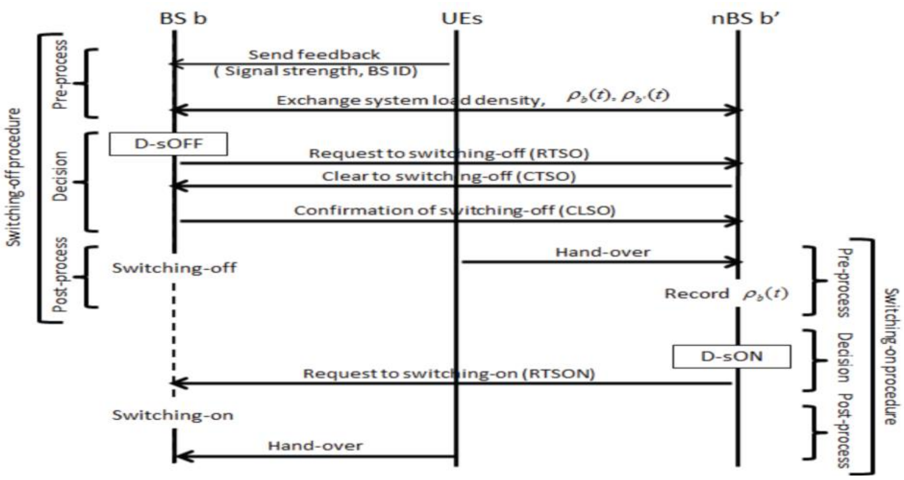

Figure 3: switching on/off procedure

TABLE I. HEURISTIC VERSION OF SWES

Algorithm	External information from neighboring BS	Internal information from mobile equipment
SES(1,1)	Required	Required
SES(1,0)	Required	Not required
SES(0,1)	Not required	Required
SES(0,0)	Not required	Not required

IV. Performance Analysis

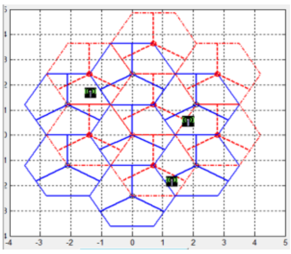

Figure 4 : Network Formation calculation

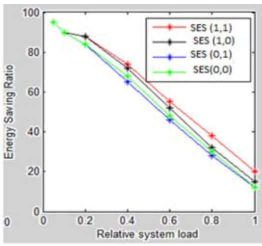

Figure 5: Energy saving graph

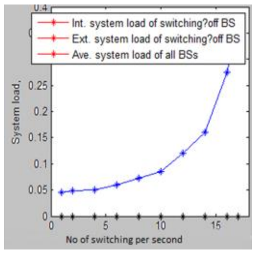

Figure 6: switching speed

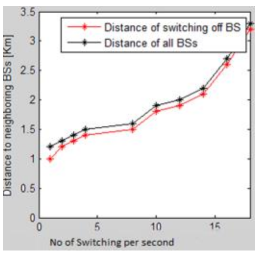

Figure 7: Average distance from BS to its neighboring BSs off BS

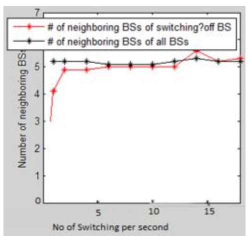

Figure 8: Average no of neighboring BS of the switching-

For our simulation we consider a LTE network topology consist of three base station in the 2km X2km geographical area shown in fig 4. We treat the full system relative traffic load =1, and set the threshold traffic values of lower threshold level = 0.4 and high threshold level =0.8. From the simulation result the number of switching per minute is calculated in figure 6. We use the typical values of transmission power for base station as given in [2], i.e., pi = 20W per second. By this switching calculation we can easy to calculate the Energy saving ratio. For our analysis we just imagined the heuristic versions of algorithm. In fig 5 just simply calculated the SES version and average traffic load (0.6). Fig 7, 8 shows the average distance between neighboring BSs and their neighboring calculations.

V. CONCLUSION

In this paper we focused on the problem of energy saving in Metropolitan area network of LTE networks and we concentrate only on the Switching based Energy Saving method in base station. Our proposed system reduced the implementation difficulty and to reduce signaling overhead the versions of SES is imagined. And our proposed method doesn't need any centralized controller and it is practically implementable. The energy saving can be archived up to 50-60% .

We only focused on metropolitan Area Network. In future it can be calculated as the micro, macro and wi-fi applications.

And we concentrate only on downlink frequency. Another possible extension is concentrate on uplink as well as uplink frequency jointly

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