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Energy Saving and Handover Decision Algorithm for Cellular Base Station Comunication Systems in Nigeria

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Abstract— *The energy consumption at the base station accounts for more than 60% of the total energy consumption of the cellular network. Due to space time characteristics of the traffic, base station cannot allocate resources reasonably, which results in wasting energy consumption. In this research work we presented an Energy saving and hand over decision algorithm (ESHODA) which is based on load balancing in a heterogeneous network. All base station will continuously be in a state until there's a change in the traffic. As the number of user equipment change the algorithm put to sleep base stations that are having less number of user and hand over users to nearby base station or back to the macro base thereby reducing the energy consumption at those site. As the traffic reduced further more of the pico base station were put to sleep mode as user allocated to them were less than average. This offers better energy saving at lower traffic. When the traffic begins to increase these pico base station will be turn back on to compliment the increase in interference due to traffic. The energy saving and hand over decision algorithm was implemented in Matrix Laboratory (MATLAB). The developed algorithm was compared with the relevant specification of the 3rdGeneration Partnership Project (3GPP) Always-on scheme. The results show that the developed sleep mode algorithm achieved an improvement of up to 75% and 50% in terms of energy savings for the pico cells at low and medium traffic, respectively. For the overall heterogeneous network, the improvements of 9.89% and 7.18% were achieved for low and medium traffic, respectively and quality of service was not affected.*

Keywords— *Heterogeneous network, user equipment, pico eNodeB, micro eNodeB, configuration 1*

I. INTRODUCTION

Interaction between human beings and their environment has to do with the way we communicate with each other, the environment arround us and the outside world. Information and communication technology (ICT) systems consume upto 10% of the world energy accounting for about 2% of global CO_2 emmision. The grid power supply is a major concern in Nigeria and has affected telecom operations in terms of costs and reliability. More than half of the sites are off-grid and usually powered by diesel generators with huge operational expenditure (OPEX) (Lorincz *et al.* 2012). The remaining grid-connected sites suffer due to the poor quality of power supply and frequent outages lasting long hours. This has led to a heavy dependence on diesel generators for the grid connected sites as well such coverage alternations are expected to be performed gradually providing a smooth handover of user's equipment's (UEs) towards new cells avoiding sudden movements and eliminating outage. In addition to the poor grid power supply, Nigerian telecom tower operators face operation challenges. Site security, for example, is a major issue as there have been several cases of damage to tower assets across the country. This risk has hindered mobile network operators (MNOs) and Tower Companies from investing in green power alternatives for the network. Vandalization of equipment and fuel pilferage have affected the OPEX of telecom sites (Oyedepo, 2012). The lack of support from the government in providing policy guidelines and security to telecom infrastructure adds to the operational complexity and costs of running a telecom network in Nigeria.

The energy crisis, which has engulfed Nigeria for almost two decades, has been enormous and has largely contributed to the incidence of poverty by paralyzing industrial and commercial activities during this period. The Council for Renewable Energy of Nigeria estimates that power outages brought about a loss of 126 billion naira (US$ 984.38 million) annually. Apart from the huge income loss, it has also resulted in health hazards due to the exposure to carbon emissions caused by constant use of 'backyard generators' in different households and business enterprises, due to unemployment, and high cost of living leading to a deterioration of living conditions (Oyedepo, 2014).

The purpose of this reseach article is to see how to tackle the non load energy consumption proportionality of base station which are the major causes behind the substantial amount of energy wasteage in cellular access networks in nigeria, especially in the low traffic periods which can be of advantage (Ambrosy *et al.*, 2012). The existing dynamic switching off/on energy saving algorithm of LTE cellular access network base station was develop using constant base station power consumption model. This leads to non-load-energy consuption proportionality of the base station which result to an increased energy consumtion at low traffic preiod (Zhinsheng *et al.*, 2010). Consequently there is need to develop a robust dynamic energy saving algorithm for LTE mobile access networks that will incorporate the load-proportional power consumption model of base station and allowing all base station under a cluster coordinate with neighbouring base station to turn off/sleep the least loaded base station through load sharing with any moderately loaded base staion.

The aim of this research article is to see how a develop an energy saving algorithm for cellular base station comunication systems in the following order:

To adopt a traffic model of user in a homogeneous cellular network using the 3rd generation Partnership Project standard.

To develop an algorithm for macro pico cells base station energy saving and hand over decision algorithm in heterogeneous network using software.

To evaluate the performance of the algorithm base on energy saving and compare it with 3rd Generation Partnership Project (3GPP) standard

II. SYSTEM MODEL

Developed Sleep Mode Algorithm

In the 3GPP always-on scheme, the standard is having all the pico cells always on irrespective of traffic load conditions, i.e. there is no on/off adaptation of macro cells. Macro and Pico cells that form an overlay layer on the existing macrocell network offer tremendous potential in terms of satisfying high data rate traffic requirements. However, macro and pico cells deployments can pose negative energy-efficiency implications if not equipped with advanced power saving mechanisms (Alsharif *et al*., 2017). In order to efficiently reduce power consumption, it is cost effective to implement sleep mode in the macro and pico cell during low and medium traffic. Therefore, a sleep mode algorithm was proposed to dynamically put pico cells into sleep mode based on traffic situations and obtained average user data rate.

The proposed algorithm requires that the average user data rate be estimated which here is once the sleep mode has been activated, then determine whether or not the pico cells will remain in sleep mode depending on a threshold limit set to (2Mbps). It usually expressed in range of minimum – maximum values which ranging's from 2Mbps – 7.5Mbps for LTE 10MHz and 2Mbps – 12.5Mbps for LTE 20MHz (Motorola White Paper, 2009). The threshold value is to ensure service delivery to users is not obstructed also for SINR interference level was set to (-2.7dB).

If the estimated average user data rate of the overall network is greater than the set threshold value, the pico cell will remain in sleep mode otherwise it will become active. As traffic increases (greater than 10 user equipment per macro area coverage) and the average user data rate goes below the threshold value, the algorithm will dynamically change the operating state of the pico eNodeB cells to active. The flow chart of the proposed developed sleep mode algorithm is given in Figure 1 with additional codes we modify the system level simulator toolbox in MATLAB.

III. SIMULATION SETUP

The 3GPP specified standards for HetNet Configuration 1(rural environment) and Configuration 4b (urban environment) will be used. These will be implemented in the system level simulator toolbox in MATLAB, in order to implement our energy saving and hand over decision sleep mode algorithm for this research work, additional codes will be written and added to the codes developed by Acharya *et al.*, (2014) in the system level simulator toolbox in MATLAB. The simulation area involves 21 hexagon cells with wrap around which simulates an infinite hexagonal grid of macro base stations as shown in Figure 2 The inter site distance between macro base stations is 500m. Each macro site covers 3 cells (3 sectors, each sector is an eNodeB cell), and there are 7 macro sites. So the total number of macro eNodeB cells is 21 (i.e. 3 eNodeB cells in 1 macro site multiplied by 7 macro sites). The macro sites use 3 directional antennas to provide coverage in 3 cells. The pico nodes will be placed along with the macro base station within the cell area to offload the traffic from the macro base station and the number of pico nodes in each cell is constant. The pico base station used omni directional antennas for transmission and cell zoomed out (Gundawar *et al.*, 2015).

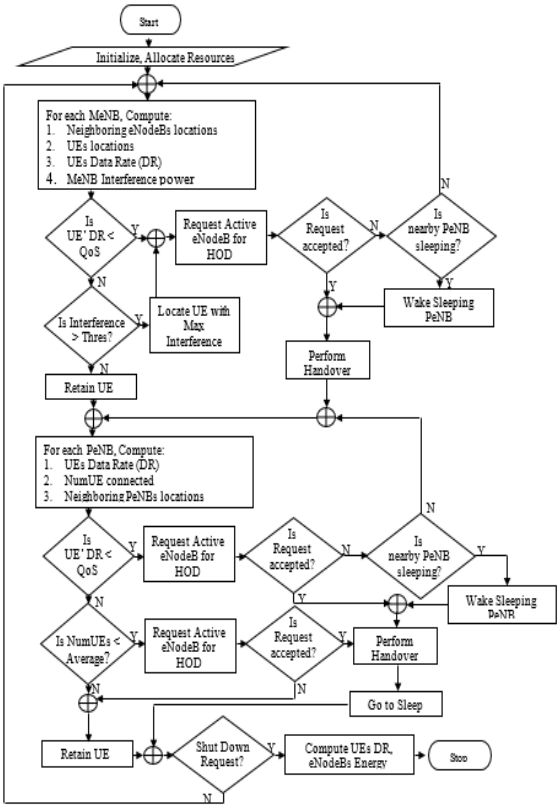

Fig. 1. Flowchart for Energy saving and handover decision algorithm (ESHODA)

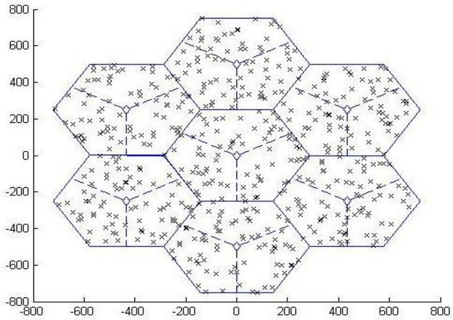

Fig. 2. HetNet Configuration1 Topology with 25 UE per macro cell area

Hence there are 4 pico eNodeB cells in each macro eNodeB cell, and there is a total of 21 macro eNodeB cells. Therefore, there are 84 pico eNodeB cells in the whole HetNet configuration. The UEs are denoted by a star.

TABLE 1: Simulation Parameters (TR 36.814 V9.0.0, 3GPP 2010)

Parameters	**Description/Values**
Cell layout	7 Hexagonal MeNBs with 3 Sectors
Total Number of MeNB	21
Total Number of PeNB	84
Number of Antennas/Sectors for PeNB	1
Number of Antennas/Sectors for MeNB	1
MeNBs radius	500m
System bandwidth	10MHz
Number of resource blocks	50
Number of PeNBs per sector	4
Hotspot radius	40m
Minimum distance MeNBs and PeNBs	75m
Minimum distance between PeNBs	40m
Minimum distance between MeNBs and UE	35m
Minimum distance between PeNBs and Ues	10m
Transmission power MeNBs	46 dBm (40W)
Transmission power PeNBs	30 dBm (1W)
Pathloss MeNBs	128.1 +37.6log (r) [km]
Pathloss PeNBs	140.7 +36.7log(r) [km]
Number of UEs per sector	60 in config4b, 25 in config1
UE distribution	Clustered and uniformly distributed
Link Adaptation	QPSK (1/5 to 3/4), 16-QAM (2/5 to 5/6) & 64-QAM (3/5 to 9/10) CQI reporting every 1ms

TABLE 2: Power Consumption Parameters (Abdulkafi *et al.* 2013)

Base Station Type	**Ai (W)**	**Bi (W)**
Macro	21.45	354.44
Pico	5.5	38

For us to obtain the power consumption for the base station, the power consumption equation for a base station according to Richter *et al*. (2009) was adopted as expressed by equation (1).

$$P_{Ci} = N_{sec} N_{ant} (A_i P_{TX} + B_{i)} \qquad (1)$$

where: $N_{sec}$and N_{ant} denote the number of sectors of the eNodeBs and the number of antennas per sector, respectively. $\mathrm{P_C}$ is the average total power per base station in Watts and $\mathrm{P_{TX}}$ is the power fed to the antenna. The coefficient $A_i$accounts for the part of the power consumption that is proportional to the transmitted power, which includes radio frequency amplifier power and feeder losses. While $B_i$denotes the power that is consumed independent of the average transmit power which include signal processing and site cooling (Abdulkafi *et a*l., 2013). The values for A_i and B_i are given in Table 2.

For the power consumption of macro eNodeB, equation (1) was modified by Richter *et al*. (2009) and expressed in equation (2).

$$P_{Cmacro} = N_{sec} N_{ant} (A_{i\{macro\}} P_{TX\{macro\}} + B_{i\{macro\})} \qquad (2)$$

where: P_{Cmacro} is the power consumption of the macro eNodeB in Watts, $\mathrm{P_{TX\ macro}}$ is the transmit power of the macro eNodeB in Watts, $A_{i\{macro}$ and $B_{i\{macro\}}$ are the coefficients $\mathrm{A_i}$ and $\mathrm{B_i}$ for the macro eNodeB respectively.

Substituting for values of N_{sec}, N_{ant}, $A_{i\ \{macro}$, $P_{TX\{macro\}}$ and $B_{i\{macro\}}$ into Equation (2), the
power consumption of a macro eNodeB was obtained as;

$P_{Cmacro} = 1\ x\ 1\ (21.45 \text{ x } 40 + 354.44) = 1212.44W$

Similarly, the pico eNodeB power consumption was obtained using equation (1) and modified by Richter *et al*., (2009) as expressed by Equation (3):

$$P_{Cpico} = N_{sec} N_{ant} (A_{i\{pico\}} P_{TXpico} + B_{i\{pico\}}) \qquad (3)$$

where: P_{Cpico} is the power consumption of the pico eNodeB in Watts, $\mathrm{P_{TXpico}}$ is the transmit power of the pico eNodeB in Watts, $A_{i\{pico\}}$ and $B_{i\{pico}$ are the coefficients $\mathrm{A_i}$ and $\mathrm{B_i}$ for the pico eNodeB respectively.

Substituting for values of N_{sec} , N_{ant} , $A_{i\{pico\}}$, P_{TXpico} and $B_{i\{pico\}}$ into Equation (2), the power consumption of a pico eNodeB was obtained as;

$P_{Cpico\ =}\ 1\ x\ 1\ (5.5\ x\ 1 + 38) = 43.5W$

For the overall power consumption of the HetNet, the Pc_{macro} obtained using equation (2) was multiplied by the total number of macro eNodeB cells, and the Pc_{pico} obtained using Equation (3) was multiplied by the total number of pico eNodeB cells.

$$P_{CT} = x \,.\, P_{Cmacro} + x \,.\, y \,.\, P_{Cpico} \qquad (4)$$

where: P_{CT} is the total power consumed in Watts in the overall HetNet, Pc_{macro} andPc_{pico} are the power consumed in Watts by the macro eNodeB and pico eNodeB respectively.x is the number of macro eNodeB (21 cells) while y is the number of pico eNodeB (4 cells).

Substituting the values for x, y, Pc_{macro} and Pc_{pico} into equation (4), the total power in the network was obtained as;

$P_{CT} = 21\ (1212.44) + 21\ (4)\ 43.5 = 29.1kW$

Data Rate Model

The data rate model used here was Khirallah *et al*., (2014) as Equation (5)

$$SINR = P_{TX} + G_{TX} + G_{RX} - N - I - SF\ (d) - PL(d) - PLN \qquad (5)$$

where: P_{TX} is the eNodeB transmission power (per cell sector); G_{TX} and G_{RX} are the eNodeB and UE antenna gains respectively.N and I are the noise and the inter-cell-interference (ICI) power from all the interfering eNodeB at the UE location respectively. PLN is the wall penetration loss for signals received by indoor UE. Finally *PL(d)* and $SF(d)$ are the path loss and shadow loss in dB respectively measured at different UE position.1

Link adaptation will require the selection of a proper (MCS) Modulation and Coding Scheme for the channel quality which is usually indicated by the SINR reported by each UE (Wang, 2010).

IV. RESULTS AND DISCUSSION

Here plots describing the condition of the HetNet scenarios during simulations that are generated are discussed.

Power Consumption

The power consumption for the various evolved nodes (macro eNodeBs (MeNB) pico eNodeBs (PeNB)) and all the eNodeBs in the HetNet (AlleNB)) was obtained using equation (1) to (4) were used in developing the power consumption model. The performance evaluation for the power consumption of the Developed (ESHODA) sleep mode algorithm was carried out by comparing it with the 3GPP Always-on scheme.

(a) Response for Average UE Data Rate and Power Consumption when the traffic is high,

During high traffic, sleep mode was not activated because the network is at its peak (25 and 60 UE per cell for Configuration 1 and Configuration 4b respectively). All the macro eNodeB and (84) pico eNodeB cells are active.

Here the network is put at its maximum having all the eNodeB awake and fully functional, the entire network is considered and the network is fully loaded having UEs spread randomly across the entire cells, for the data rate Khirallah *et al.*, (2014) model was used to determine the average UE data rate for the Pico, macro and the overall network. The average UE data rate performance evaluation was compared with that of the 3GPP always on scheme.

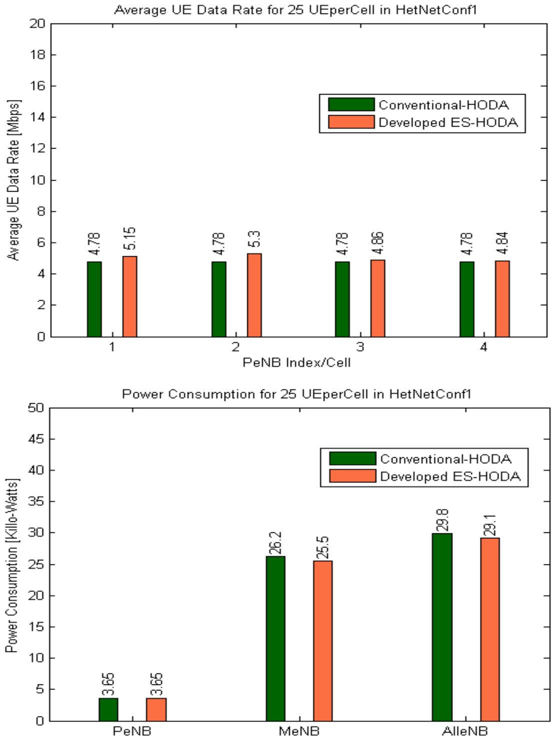

Fig. 3. UE per cell in HetNet Configuration1(a) Average data rate for 25 UE and (b) Power consumption for 25UE

In figure 3 (b) the power consumption looks nearly the same but there is improvement in figure 3(a) data rate for the developed (ESHODA) than the Always-on Scheme at high traffic (25 UE per cell for Configuration 1) This because, none of the pico cells was in sleep mode.

In figure (4) for the configuration 4b (b) during high traffic the macro eNodeB has considerable reduction in power consumption this is as a result of the pico eNodeB being active and its carrying lesser load offloading it to the pico eNodeB and so there is also improvement on the overall network with the ESHODA performing better than the conventional always on scheme.

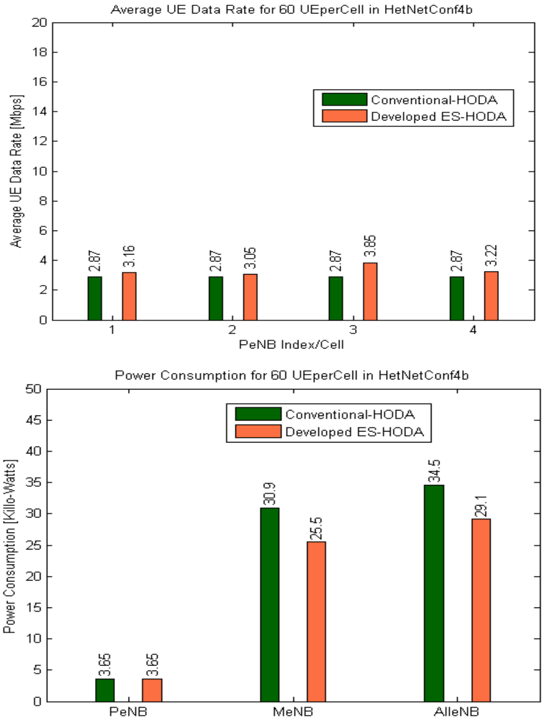

Fig. 4. UE per cell in HetNet Configuration4b (a) Average data rate for 60 UE and (b) Power consumption for 60UE

To determine the total power saved we use the already equation 6 This is obtainable from the total power of the Always-on scheme ($P_{Always\ \_On)}$ and the Developed algorithm ($P_{Sleepmode}$). Therefore, power saved (P_S)

$$P_S = P_{Always\ \_On} - P_{Sleepmode} \qquad (6)$$

$$P_S = (34.5 - 29.1)\ kW = 5.4kW$$

(b) Response for Average UE Data Rate and Power Consumption when the traffic is low

From Figure 5(a) and 6(a), it can be observed that average UE data rate for the Always-on scheme is the same for all the four pico cells when the traffic is minimal (5 UE per cell in both Configuration 1 and Configuration 4b). With the developed algorithm, only one of the pico cells is active providing a data rate of 3.73Mbps and 6.04Mbps respectively, for the connected UE while the other three cells are in sleep mode. These average UE data rate values still exceed the minimum data threshold. Some of the UEs are connected to the MeNB, and only one pico cell is sufficient to provide the required data rate to the pico cell users even though the Always-on Scheme is higher. The cells with an average UE data rate of zero for the developed (ESHODA) sleep mode algorithm are in sleep mode in other to reduce power consumption. There are no users connected to the sleeping cells. A UE is either connected to the active pico cell or the MeNB. In Figure 5 (a) Cells 1, 2 and 3 are in sleep mode and Figure 6(a), Cells 1, 3 and 4 are in sleep mode.

When the traffic is low, the power consumption of the macro eNodeB remains unchanged for both algorithms due to the fact that the sleep mode was only implemented for the pico PeNB cells which also applies to Configuration 1 and 4b.

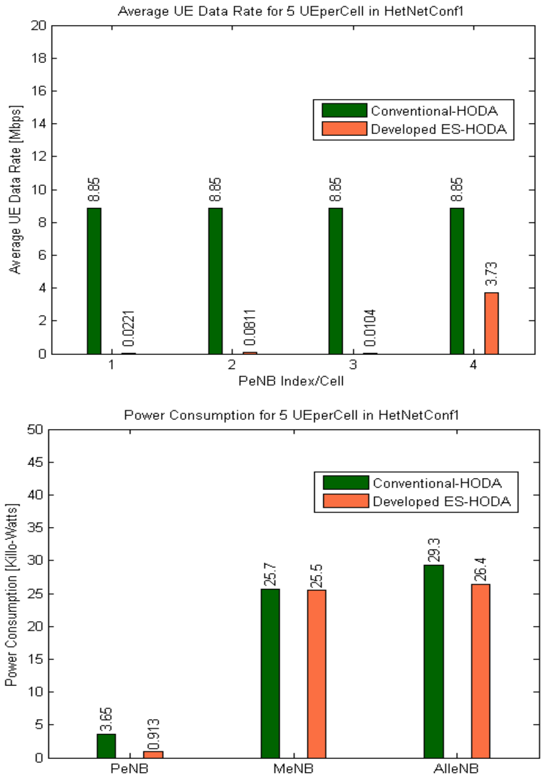

Fig. 5. UE per cell in HetNet Configuration1 (a) Average data rate for 5 UE and (b) Power consumption for 5UE

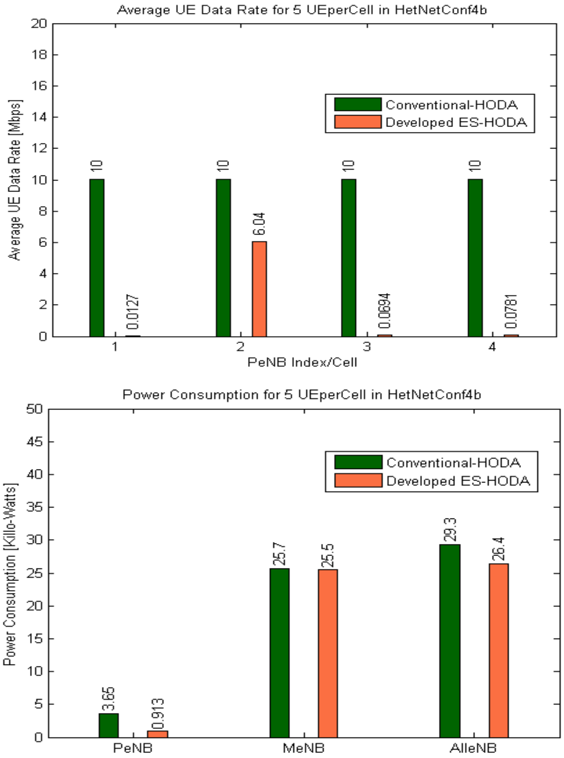

Fig. 6. UE per cell in HetNet Configuration4b (a) Average data rate for 5 UE and (b) Power consumption for 5 UE

It will be observed that there was a decrease in the power consumption for the overall HetNet (AlleNB) as a result of improvement in the PeNB power consumption during low traffic. To calculate the percentage improvement in the reduction of power consumption, Equation (7) was used.

$$P_{Saving} = \frac{PAlways\_on - Psleepmode}{PAlways\_on} \times 100 \qquad (7)$$

Where: P_{Saving} is the amount of power saved, $P_{Always\ \_on}$ is the power consumed with Always-on scheme and $P_{Sleepmode}$ is the power consumed in sleep mode.

Now, substituting the values from Fig. 5(a) into Equation (7), the amount of power saved within the PeNB was obtained as;

$$P_{Saving} = \frac{3.65-0.913}{3.65} \times 100$$

$$P_{Savings} = 75\%$$

While the amount of power saved in the overall HetNet was obtained as expressed below.

$$P_{Total\_Saving} = \frac{29.1-26.4}{29.1} \times 100$$

$$P_{Total\_Saving} = 9.89\%$$

From the mathematical expression power savings of about 75.0% and 9.89% was achieved for the PeNB and AlleNB respectively. With the developed (ESHODA) sleep mode algorithm when compared to the always-on scheme in Configuration 1. The Same results were obtained for Configuration 4b.

(c) Response for Average UE Data Rate and Power Consumption When the traffic is medium,

As the number of user equipment per cell increases (at medium traffic) and All UE data reduces below the set threshold, some of the pico cells become active dynamically in the case of the Developed algorithm so that the quality of service is not obstructed.

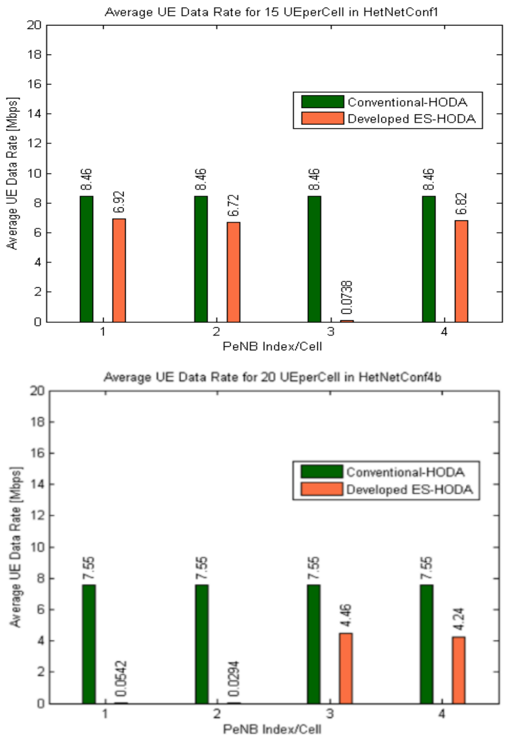

Fig. 7. UE per cell in HetNet Configuration1 (a) Average data rate for 15 UE and (b) Average data rate for 20 UE in configuration 4b.

The ESHODA was able to determine the required number of pico cells that should become active to provide a good data rate for the UE. From Figure 7(a) and (b), three or two Pico cells are now active. i.e. an additional one Pico cell was added to the initial one Pico cell serving the UE.

When the number of user equipment per cell became minimal (15 UE per cell) for configuration1 and (20UE per cell) for configuration4b the sleep mode was still active thereby having only one non active pico cell when there's no connected user equipment and up to two pico cells in configuration 4b. It is observed from Figure 7(a) that the AllUE Data is not less than the set threshold of 2Mbps so the pico cells in sleep mode remained in that state, while those connected to the active cell get up to 6.92Mbps

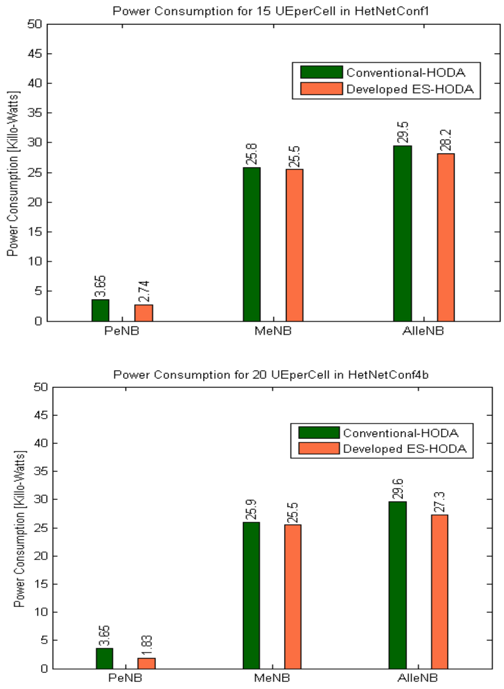

Fig. 8. Power consumption UE per cell in HetNet (a) Configuration1 5 UE and (b) Configuration4b 5 UE

When the number of user equipment increased, the power consumption for the developed (ESHODA) sleep mode algorithm becomes lower than the always-on scheme, as half the number of pico eNobeB will be on and the other half off. So considering 15UE for the rural Configuration 1 and 20UE for the configuration 4b.

Taking configuration 1 into consideration

$$P_{Pico\_Saving} = \frac{3.65-2.74}{3.65} \text{ x } 100$$

$$P_{Pico\_Saving} = 25\%$$

$$P_{Total\_Saving} = \frac{29.5-28.2}{2.95} \text{ x } 100$$

$$P_{Total\_Saving} = 4.41\%$$

It can be seen that the power reduction is about 25% than in figure 8(a) and also 4.41% for the pico cell in the whole network

Taking configuration 1 into consideration

$$P_{Pico\_Saving} = \frac{3.65-1.83}{3.65} \text{ x } 100$$

$$P_{Pico\_Saving} = 50\%$$

$$P_{Total\_Saving} = \frac{29.6-27.6}{29.6} \text{ x } 100$$

$$P_{Total\_Saving} = 7.81\%$$

V. SUMMARY AND CONCLUTION

From the following simulation of average energy efficiency, power consumption and average user data for HetNet Configuration1 and HetNet Configuration4b for the overall heterogeneous network, the performance of the developed algorithm out weights that of the 3GPP always on scheme when different traffics were considered.

When configuration 1 was considered for medium and low traffic reduction in power was about 75% and 50% in the pico cells while 9.28% and 6.19% reduction was achieved for the overall HetNet for low and medium traffic respectively.

To determine the total power saved we use the already equation (5) This is obtainable from the total power of the Always-on scheme ($P_{Always\ \_On}$) and the Developed algorithm ($P_{Sleepmode}$).

$$P_S = P_{Always\ \_On} - P_{Sleepmode}$$

$$P_S = (29.3 - 26.4)\ kW = 2.9kW$$

According to Oh *et al.*, (2010) there is about 6 hours of low traffic during working days and about 8 hours on weekends and holidays. Therefore, the energy saved at low traffic on a working day is given as

$$Energy\ Saved = 2.9\ x\ 6 = 17.4kWh$$

For the energy saved during low traffic on weekends and holidays per day is;

$$Energy\ Saved = 2.9\ x\ 8 = 23.2kWh$$

Therefore, the amount of energy saved using the Developed algorithm over a period of 24 hours is 17.4kWh and 23.2kWh for a working day and weekend/holidays respectively. When considering the number of days for the week we would find out that there was a considerable amount of energy saved.

REFERENCES

[1] Lorincz, J., Garma, T., & Petrovic, G. (2012). Measurements and modelling of base station power consumption under real traffic loads. *Sensors*, *12*(4), 4281–4310. https://doi.org/10.3390/s120404281

[2] Oyedepo, S. O. (2012). Energy and sustainable development in Nigeria : the way forward. *Energy, Sustainability and Society*, *2*(1), 1. https://doi.org/10.1186/2192-0567-2-15

[3] Oyedepo, S. O. (2014). Towards achieving energy for sustainable development in Nigeria. *Renewable and Sustainable Energy Reviews*, *34*, 255–272. https://doi.org/10.1016/j.rser.2014.03.019

[4] Ambrosy, A., Auer. G., Blume, O., Caretti, M., Eilenberger, G., Erdem, A., Fantini, R., Fazekas, P. et al. (2012). Definition and parameterization of reference systems and scenarios. *EARTH Project Report*, *DeliverableD2*.2(pp. 1-87)

[5] Alsharif, M. H., Nordin, R., & Ismail, M. (2013). Survey of Green Radio Communications Networks : Techniques and Recent Advances, *2013*.

[6] Motorola White Paper, (2009). Realistic LTE performance – from peak rate to subscriber experience. *White Paper*. www.motorola.com

[7] Acharya, j. Gao, L. and Gaur, S. (2014). *Heterogeneous Network in LTE-Advanced.*

[8] Abdulkafi, A. A., Tiong, S. K., Chieng, D., Ting, A., Ghaleb, A. M., & Koh, J. (2013). Modeling of Energy Efficiency in Heterogeneous Network, *6*(17), 3193–3201.

[9] Richter, F., Fehske, A., & Fettweis, G. (2009). Energy efficiency aspects of base station deployment strategies for cellular networks. *In Proc. of IEEE Vehic. Technol. Conf. (VTC Fall)*, Anchorage, USA. (pp. 1-5).

[10] Khirallah, C., Rastovac, D., Vukobratovic, D., and Thompson, J. (2014). Energy Efficient Multimedia Delivery Services over LTE/LTE-A. *IEICE Transactions on Communications*, **97**(8): 1504-1513.
[11] Oh, E., & Krishnamachari, B. (2010). Energy Savings through Dynamic Base Station Switching in Cellular Wireless Access Networks, 0–4.
[12] Technical Report 36.814 v.9.0.0, (2010). Technical Specification Group Radio Access Network: further advancements for E-UTRA physical layer aspects, 3GPP Release 9 (March).
[13] Zhinsheng, N., Yiqun, W., Jie, G., &Zexi, Y. (2010). Cell zooming for cost-efficient green cellular networks. *IEEE Communications Magazine, vol. 48,* (pp. 74-79).
[14] Gundawar, P. S., Dorge, P. D., & Gode, C. S. (2015). Optimization of base station power using cell zooming technique. *International Journal of Advent Research in Computer and Electronics (IJARCE),* Vol. 2, No. 1, (pp 16-21).
[15] Wang, Y. (2010). *System Level Analysis of LTE-Advanced: with Emphasis on MultiComponent Carrier Management. PhD Thesis,* Department of Electronic Systems, Faculty of Engineering and Science, Aalborg University.