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ENHANCED TRANSMISSION ENERGY EFFICIENCY IN AN LTE HETEROGENEOUS NETWORK USING ADAPTIVE CELL SELECTION ALGORITHM

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Abstract:

This paper presents enhance transmission energy efficiency in an LTE heterogeneous network using adaptive cell selection algorithm. This was embarked on to maintain quality of service which has not been achieved constantly in the existing system. The problem was addressed developing an adaptive cell selection algorithm which ensured that when the signal strength of a cell is below standard, the cell handover neighbouring one which has better performance. This algorithm was implemented with Simulink and evaluated. The result showed that the signal strength was maintained from at -90.16dB as against -105.8 in characterized. The implication o this result when analysed with the ITU-T standard showed that the quality of service in the network with adaptive cell selection algorithm was maintained with 10.5% energy conservation improvement and energy efficiency achieved is 54%.

Keywords: **Cell selection, Broadband, HetNet, Transmission energy, Cell Station, Base Station**

1. INTRODUCTION

According to the International Telecommunication Union (ITU), over 9 billion mobile phone users and over 4.2 billion active subscribers of mobile broadband networks are currently in the world's information and communication domain. The implication of this analysis shows that network services data rate, traffic, and users will continue to increase exponentially all around the world as more users are connected on daily basis. This increase in user equipment and data rate presents the need for more robust Information Technology (IT) Infrastructures to manage traffic and improve the quality of service. However, the main issue remained the amount of energy consumed by this IT system during the management of the communication process.

Today the cost of running telecom companies and the amount users have to pay for service provision has remained a major problem that has kept the users and admin unsatisfied. One of the major reasons for this problem remains the high cost of energy consumed by many telecom devices and hence led to increased service charges. This research solved this problem using an adaptive cell selection algorithm which used the best cell within the environment in a heterogeneous network to transmit or receive data. This when achieved will improve routing and throughput performance and energy efficiency and hence reduce the cost of services.

According to (Konishi, 2013), HetNet is an area of much interest today due to the ability to accommodate traffic increase through the long-term evolution of an advanced system in the third generation partnership project. However, despite the advantage offered by the HetNet such as the increase in broadband and limited cost of energy during communication, the deployment brings about certain challenges as a result of the variation in power transmission from one base station to another. This leads to uneven distribution of load traffic among various base stations, thus underutilizing the resource at low power and energy efficiency, thus leaving the gap for improvement.

Therefore this research is aimed at developing an improved cell selection algorithm to enhance transmission energy efficiency in long-term evolution (LTE)-An advanced heterogeneous wireless cellular system.

2. MATERIALS AND METHOD

2.1 Materials Used

The materials used for this research are listed below;

- Laptop
- Multi connector port
- MTN Modem
- Vector signal software (Software for LTE data collection)
- Excel software, etc

2.2 METHOD

The data collected was done from the eNodeB device of the base pico station. This device was logged in using the SMW200A vector signal software to gain access to the user equipment data log and collected data of key performance indicators for transmission energy efficiency which is the power consumed per various times in hour of user activities. The result is presented in the table 1;

Table 1: Characterized data

Time (hr)	Signal Power (dB)
01:00	-99
02:00	-97
03:00	-97
04:00	-99
05:00	-98
06:00	-102
07:00	-109
08:00	-105
09:00	-109
10:00	-109
11:00	-107
12:00	-103
13:00	-103
14:00	-109
15:00	-109
16:00	-107
17:00	-109
18:00	-109
19:00	-109
20:00	-109
21:00	-105
22:00	-105
23:00	-105
24:00	-109
Average	-105.8

The data in table1 presented the performance of a pico cell station within 24 hours. The data analyses are analysed in the chapter four.

3. MODEL OF THE TRANSMISSION ENERGY EFFICIENCY

This presented the model of transmission energy efficiency using the relationship between the receiver power, the transmitter power, the gain for the transmission, reception and gain as shown in equation 1;

$$P_r = P_T \frac{G_{Tx} G_{Rx}}{4\lambda d/\lambda^2} \qquad 1$$

Where;

Pr = Receive power at distance dd from the transmitter
P_T= Transmit power
G_T= Gain of transmitting antenna
G_R= Gain of receiving antenna
λ = Wave length
d = Distance between the transmitter and receiver

3.1 Signal to Interference to Noise Ratio (SINR)

The model presented the signal to noise to interference ratio of the base station carrier packet as sown below;

$$\mathrm{SINR} = \frac{S_c^u . Pt}{N_b + \sum_{j \neq b} I_j^u} \quad 2$$

Where N_b is the noise from the background, S_c^u is the allocated signal from the user cell station defined as b, based on normal sub carrier u or reduced power sub carrier resource block c; I_j^u is the interfering signal from other scheduled cell station j detected by the user equipment u; P_t is the power of transmission in the cells and interference for each of the user is affected by Rayleigh fading and user channel are assumed independently.

3.2 Base Station Power model

This model was used to compute the power consumed by the base station during the time of operation. The model was developed using the summation of the overall energy consumed by the components on the base station during transmission or receiving of data.

$$E_k = \sum_{i=1}^{N_e} T_i p_{k,Tx}(S_{k,Tx};\ u_{k,Tx};\ L_{k,Tx}, L_{k,Tx-1}) \quad 3$$

Where N_e is the number of user equipment (UE) service request in the base station within a given time (T_x), T_i is the time between data transmission and reception, p_k is the power consumed for each equipment within the base station, $S_{k,Tx}$ is the state of the UE, $L_{k,Tx}$ is the BS.

4. DEVELOPMENT OF THE PROPOSED ADAPTIVE CELL SELECTION ALGORITHM

The algorithm was developed to enhance transmission energy efficiency in the base station. The aim here is to improve the routing performance of data by searching for the best cell and improve the speed of transmission to conserve energy. To achieve this, algorithm which used fitness test to check and determine the best route to the destination path and then use the matrix for the data transmission. The algorithm is presented below while the flow chart is in figure 1;

Start

1. Identify frequency carrier of the BS
2. Initialize cross correlation model in equation 3.5
3. Determine the number of enodeB information (signal strength and SINR)
4. Compute reference signal strength and SINR
5. Determine the best signal strength and SINR using the reference values computed
6. If
7. Transmission =true
8. Then
9. Identify cell with highest Signal strength and SINR value
10. Transmit carrier
11. Else if (reception) = true
12. Then
13. Identify cell with highest Signal strength value
14. Receive carrier
15. Return
16. End

5. IMPLEMENTATION OF THE MODELS

The system was implemented using Matlab script and the modules of the algorithms achieved using signal processing toolbox, LTE toolbox, communication tool box and optimization toolbox. This tool box was designed using the mathematical models developed in the previous section guided by the setting of the 4G network base station collected from characterization as presented in table 2.

Table 2: Parameters for the programming

Parameter	**Value**
Path loss for PeNb	140.7 + 36.7log (r/km)
Path loss for MeNb	128.1+ 36.7log (r/km)
Minimum Packet Size	64 bytes
Maximum Packet Size	1500 Gb
Network Speed	10 m/s
Rate of packet generation	100kb/s
Area	500X500 m^2
MAC	Mac/802_11
Simulation Time Interval	20 sec
Transmission power for MENb	35dBm
Power of transmission for PeNb	45dBm
Frequency	10MHz at 2000MHz

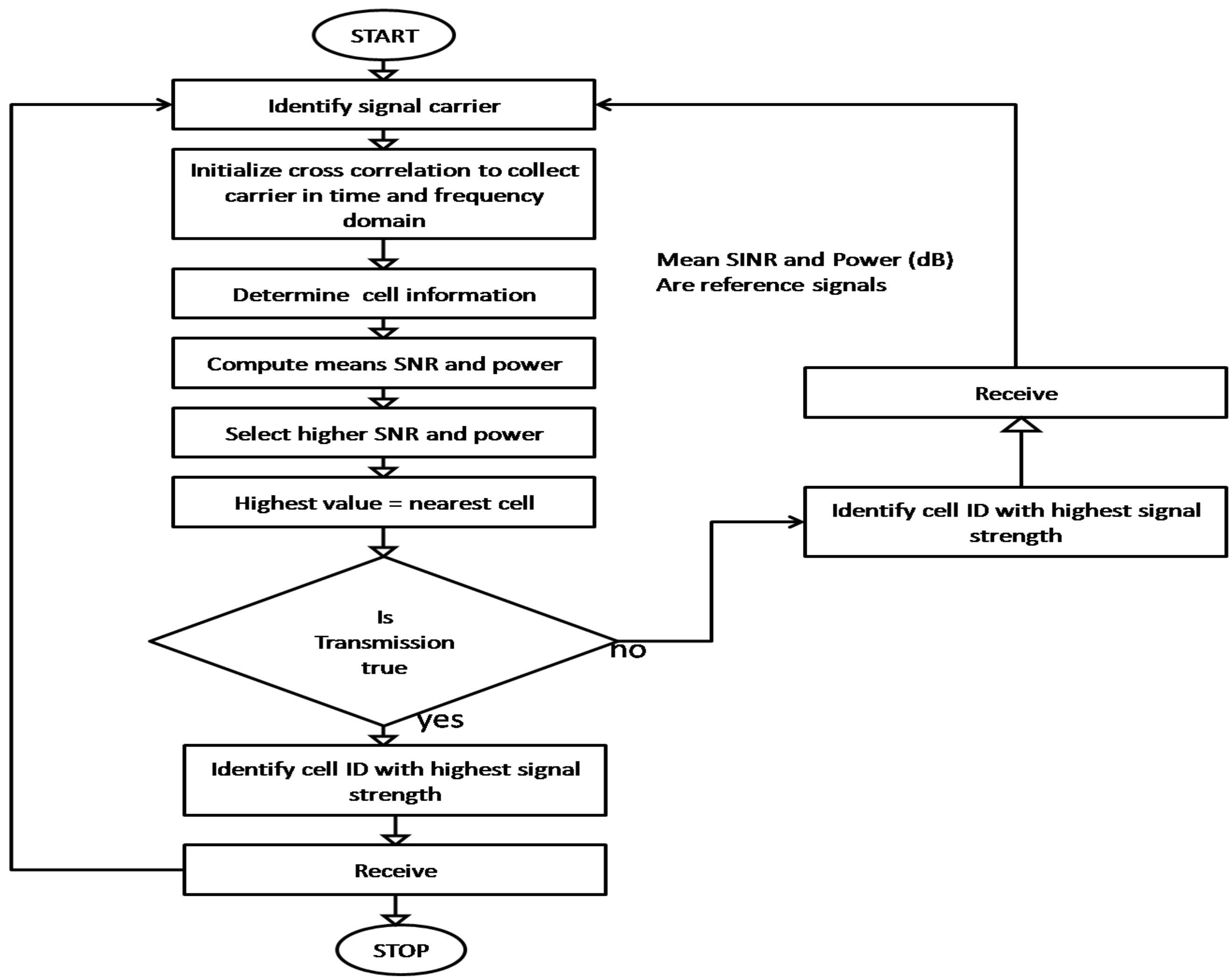

Figure 1: The algorithm flow chart

6. Test setup and Simulation of the algorithm

To setup the test bed for the heterogeneous network, antenna toolbox and Radio frequency toolbox was used to implement the Heterogeneous network (HetNet) in Simscape simulator tool. Then the algorithm developed was deployed on the Cell Network using LTE toolbox and simulated with the parameters in table 2.The user equipment was used to perform communication process while the effectiveness of the adaptive cell selection algorithm was monitored. The HetNet setup is presented in figure 3;

Figure 3: The network to test the algorithm

The figure 3 presented the two tier heterogeneous network implemented with the user equipment used to test the quality of service performance of the network. The network installed with the algorithm developed enables the user equipment to select the best cell for the transmission of data.

7. RESULTS AND DISCUSSION

This presented the result of characterization of the data collected from the testbed to analyse the power consumed by the cell during communication process. The result of the data analysis was presented in figure 4;

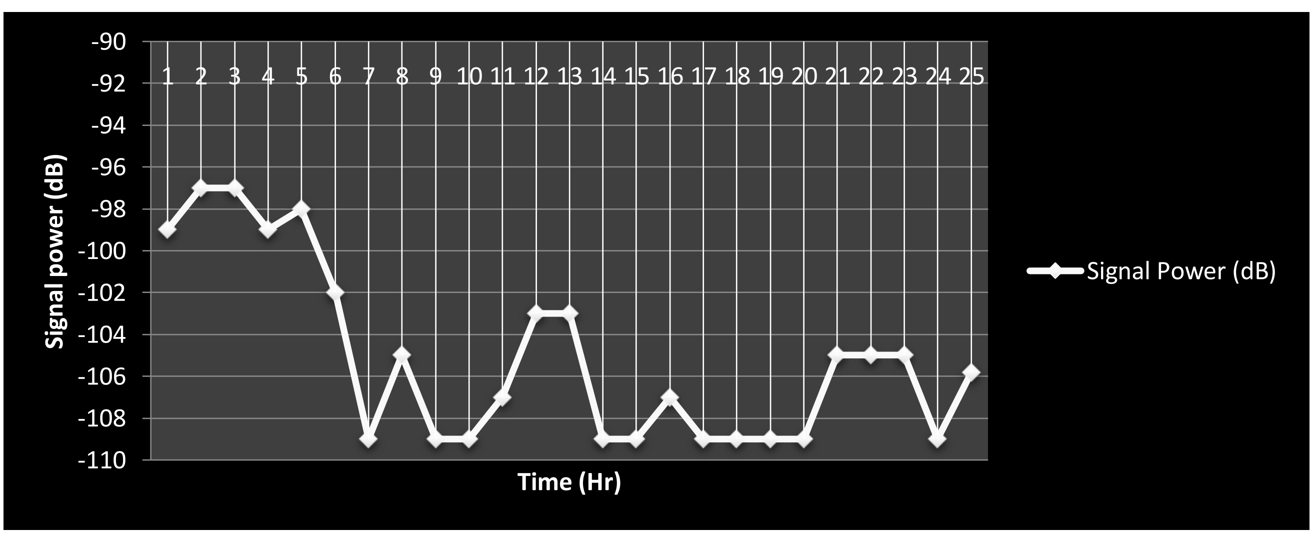

Figure 4: The signal strength of the characterized

The result in the figure 4 presented the performance of the pico cell characterized showing the variation of signal strength within 24hours. From the result it was observed that the average signal strength of the cell is

105.8dB which when compared based on the standard of the ITU-T results to poor quality of service. The implication is that the poor quality of service which will results to latency among other issues on the network will result to improved power consumption on the cell and hence high cost.

7.1 Results when one available cell is Active

This section presented the performance of the algorithm when user equipment transmitted and received signal. The algorithm was able to use the signal strengths available to adaptively select cell and make communication. The detected signal strengths available are presented in table 3 for transmission of data purpose;

Table 3: The result during data transmission

Transceiver	Cell 1	Cell 2
Cell ID	101	313
SINR (dBm)	16.00	0
RSRP (dBm)	-82.00	0
Power (W/h)	128	0

In this case the algorithm was able to collect signal strength from only one cell. The reason is that this is the only available cell signal and hence was simply selected and used for communication. The algorithm detected the signal to noise ratio (SINR) as 16dBm and reference signal receive power (RSRP) as -82dBm. The next result in table 4 presented the performance of the algorithm when receiving data.

Table 4: Result during data reception

Available Cell ID's	**Signal Strength available cells**
101	-82.00dBm
278	-108.41dBm
437	-109.49dBm

From the table 4, it was observed that the algorithm detected the signal information of the various cells using their RSRP and then used the best with RSRP of -82dB to receive the data. The analysis of the result was presented as diagram of figure 5;

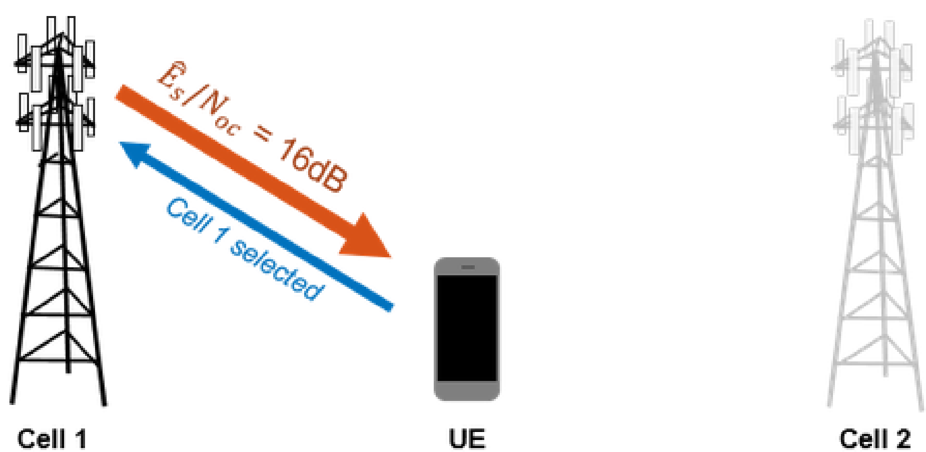

Figure 5: result when one cell is available

From the result in figure 5, it was observed that the algorithm was able to detect cell 1 which has the only information for RSRP and SNIR.

7.2 Results with two available Cells

This section presented the performance of the algorithm when tested with two available cells as shown in the figure 6;

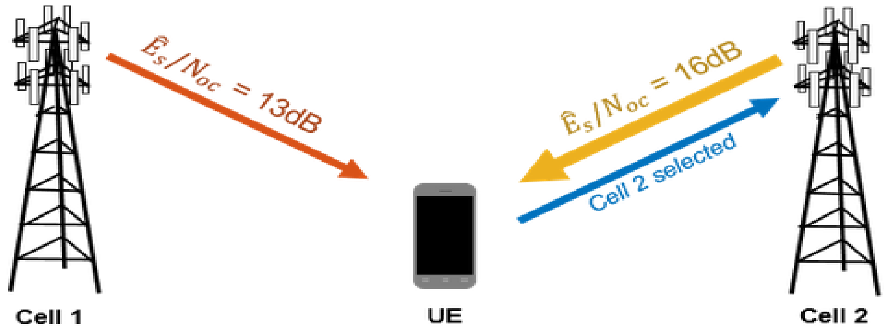

Figure 6: Performance when multi cell are active

The figure 6 presented the performance of the algorithm how it identified the available multi cell based on their SINR and RSRP and compute the best based on the algorithm developed to determine the best and then transmit the carrier.

8. CONTRIBUTION TO KNOWLEDGE

This research developed an adaptive cell selection algorithm for optimized transmission energy efficiency in 4G network

9. CONCLUSION

The need for an adaptive cell selection algorithm to optimize user experience has remained a major issue in 4G heterogeneous Networks. This issue was due to the poor quality of user experience mainly outside the cell coverage area or users at the cell edge. At this point, the cell signal strength suffers issues such as interference, high latency and loss, but due to the lack of an adaptive cell selection algorithm for handover, the problem persists. This research has successfully developed and adaptive cell selection algorithm which when the cell experiences poor quality handover to the neighboring cell with better signal strength to maintain quality of service. The algorithm was implemented with simulink and evaluated. He result showed that the signal strength was maintained at -90.16dB as against -105.8 in characterized.

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10. RECOMMENDATION

Having completed this research and tested the algorithm, the researcher recommends that the algorithm be deployed on other 4G LTE heterogeneous network for better management and stable service quality.

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