MODELLING OF INTELLIGENT HANDOVER DECISION ALGORITHM FOR 4G MOBILE NETWORK USING GENETIC ALGORITHM

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Abstract

This paper presents the modeling of intelligent handover decision algorithm for 4G mobile network using genetic algorithm. The aim is to ensure that the best cell is chosen in a heterogeneous network for the management user carriers. This was achieved developing a genetic algorithm which help the bigger cell (Macro) to make decision based on key indicator attributes like signal to noise ratio, signal to interference and noise ratio, reference signal receive power, among other attributes for quality of service in 4G network and then handover for better management. The models were developed using mathematical methods, structural methods and pseudocode for the handover algorithm. These were implemented with Simulink and evaluated. The result showed that the macro cell was able to choose the best cell available at the time of handover within the network and make decision.

Keywords: handover, 4G network, heterogeneous network, Macro cell, genetic algorithm

1. INTRODUCTION

The concept of network has dated years back in the mid 90's, and since the evolution of computer networks it has improved the manner and means of communication, data sharing among individuals at different locations on earth at any given time. The mobile wireless network industry has transformed over the years from the first generation (1G) to the present state of the art fourth generation (4G)-Advance. The aim was to improve the efficiency, speed, user experience among other user requirements for excellent quality of service. However the exponential increase in the number of subscribers presents the challenges of better management and more dynamic performance of the network infrastructure.

This increase in the use of mobile devices has led to a tremendous increase in mobile communication data traffic, thereby increasing the demand for wireless communication systems, which results to challenges to cellular network providers in terms of improving their core networks to support future network demands and keeping up with the requirements of the rate of the growing customers (Al-Shinwan et al., 2018).

One major challenge has remained the need for intelligent management of dynamics nodes. In many cases, these nodes are constantly in random motion and often migrate from one cell extension range to another and required intelligent handover decision to maintain quality of service. When a mobile terminal is connected with a network and reaches at a point where signals get weaken and communication is interrupted, as each access point or eNodeB (eNB) has a specific range to serve, then there is a need to connect with other access point or eNB to carry on communication (Ejaz et al., 2017). The process of transferring control of mobile terminal from one access point to the other is called handover (Ananthi, 2014). Handover can be horizontal or vertical (Chavan and Vanita, 2013).

Over the year, many solutions have been proposed to optimize the handover process such as the sue of artificial intelligence techniques which engaged algorithms such as fuzzy logic algorithm, Artificial Neural Network (ANN), deep learning and Genetic Algorithm (G.A) (Lee et al., 2009; Mahira and Subhedar, 2017; Yang et al., 2017; Saravanan and Prithiviraj, 2017) respectively to solve the problem of handover, however despite the success. There is need to localize these solutions to many rural communities and also there is need to develop an intelligent algorithm which considers all actors of quality of service (QoS) in 4G network and then take the handover decision. This will be achieved in this paper using genetic algorithm.

The reason the G.A was chosen ahead o other algorithms was due to its simplicity and yet very good solution to complex optimization problem like the handover problem under view. Secondly the approach will provide a timely solution to the problem as unnecessary stress of data collection, training and high cost of implementation is avoided. This paper will develop the G.A and use to optimize handover performance of 4G heterogeneous network.

II. METHODOLOGY

The methodology used for the study involves the modeling of the parameters involved in the user communication process such as the signal to noise ratio, signal to interference and noise ratio, reference signal receive power, empirical loss propagation model, and reference signal received quality. These attributes of the user by the cell was used to develop a handover decision algorithm which enables the cell to decide the correct time for handover, based on the user dynamic behavior.

III. MODELLING

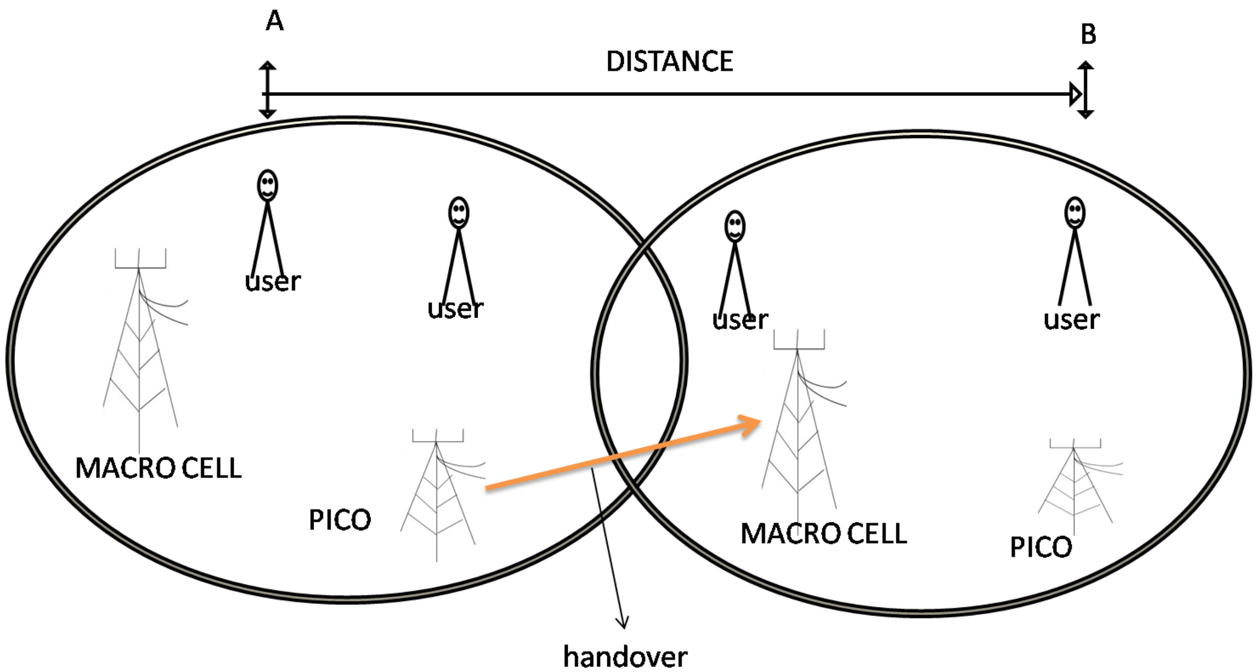

Figure 1: Model of the problem formulation

The figure 1 presents a two heterogeneous network covering distance A to B. When an active user migrates from the sector A to sector B, the cell in the sector A sends handover request to those in sector B and then handover the user carrier for continuous data management. However in many cases as modeled in the empirical area as shown in figure 1, the delay time to take this handover decision by the conventional cells, especially when the user is in a vehicle network, often results to drop calls, packet loss, among other poor quality of service and has remained a major problem. To solve this problem, the paper developed an intelligent handover algorithm which used the user data to decide when it's time for handover, so as to maintain quality service and user experience.

Signal to Noise Ratio (SNR) model

The SNR model is presents as the ratio of the real signal to noise signal as shown in equation 1;

$$SNR = \frac{P_s}{P_n} \quad (1)$$

Where P_s is real signal and P_n is noise signal. It can also be expressed in logarithmic function as;

$$SNR(dB) = 10log\frac{P_s}{P_n} \quad (2)$$

Signal-to-Interference-and-Noise-Ratio (SINR) model

From the equation 1, the interference from other cells signal was considered to provide the model in equation 2 as;

$$SINR = \frac{P_{signal}}{P_{noise}+P_{interference}} \quad (3)$$

Where $P_{interference}$ is the interference signal.

Reference Signal Receive Power (RSRP)

The RSRP was used to measure the signal strength of the User Equipment (UE) as its position changes over time. This parameter defined the specific UE as the linear average received power of the signal which carries the cell reference signal within the measurement bandwidth (Alor et al., 2019). The model of the signal strength is presented in equation 4;

$$RSRP = \frac{P_o}{N} \quad (4)$$

Where Po is the received signal power and then N is the number of resource blocks.

Received Signal Strength Indicator (RSSI)

The received signal strength indicator is similar to the RSRP, but its application is only for measurement of carrier in cells which operates with Orthogonal Frequency Division Multiplexing (OFDM) which is applicable to the MTN cell under study (Alor et al., 2019).

Reference Signal Received Quality (RSRQ)

The RSRQ was used to measure the quality of the cell based on its handover efficiency and performance. This parameter is similar to the equation 4 as is measured using the model in equation 5, (Alor et al., 2019).

$$RSRQ = 10log_{10}(N) + \text{RSRP} - \text{RSSI} \quad (5)$$

Empirical Path Loss model

This was used to measure the fading factor of distance between the user equipment and the service cell within the sectors. According to Alor et al. (2014), the propagated signal strength (Pt) decreases inversely with the square of distance as the UE travels away from the service cell into the next sector. The model for the received signal power is presented in equation 6;

$$\text{R} = \frac{P(t)}{4\pi d^2} \quad (6)$$

But pathloss (Pl) is the ratio of transmitting to the receiving power and λ = c/f, therefore

$$\text{Pl} = (\frac{4\pi}{c})fd^2 \quad (7)$$

Where c is the speed of light and F is the frequency of transmission, where c =3* 100000000. Since the signal strength is measured in dB, then substituting the value of C presented the pathloss model in equation (7) (Alor et al., 2014);

V. DEVELOPMENT OF THE GENETIC ALGORITHM

The genetic algorithm is a biologically inspired algorithm from the law of natural selection and cross mutation to produce offspring and then use rule base to solve optimization problem. The genetic algorithm was developed via the following process which are;

i. Initialization of the population which is the attributes for quality of service modeled from equation 1 to 7.

ii. Perform fitness test to test and detect the attributes as the node changes for the classification of poor quality of service and hence the need for handover. The fitness model was presented as equation 8;

$$Ft = \frac{x_i}{\sum_{k=1}^{n} \ fitness\,(x_k)} \quad (8)$$

Where x_i are the reference values for RSRP according to ITU and NCC. x_k are the number of attributes for quality of service as modeled. n is the total number of users connected within the cell.

iii. Construction of new population which is the update recorded from each step ahead fitness test and then selected for cross over

iv. Cross over is the new UE data obtained from the fitness test conducted and the process continuous until poor quality of service according to the Nigerian Communication Commission (NCC), International Telecommunication Union (ITU) standards for

THE PSEUDOCODE OF THE G.A

1. Start
2. *Initialize the population of chromosomes*
3. *Perform fitness test with equation 8*
4. *Construct new population*
5. *Selection of new of the new population*
6. *Cross over for mutation*
7. *Select new offspring*
8. *Repeat step (5; 6; 7)*
9. *Do Until*
10. *step (3) output = step (7)*
11. *send handover request*
12. *accept permission*
13. *handover user*
14. *end*

The handover decision sequence modeling

The handover decision was done using the information obtained from the G.A to know when the quality of service degraded as a result of the user position and then the need for handover using the model in figure 2;

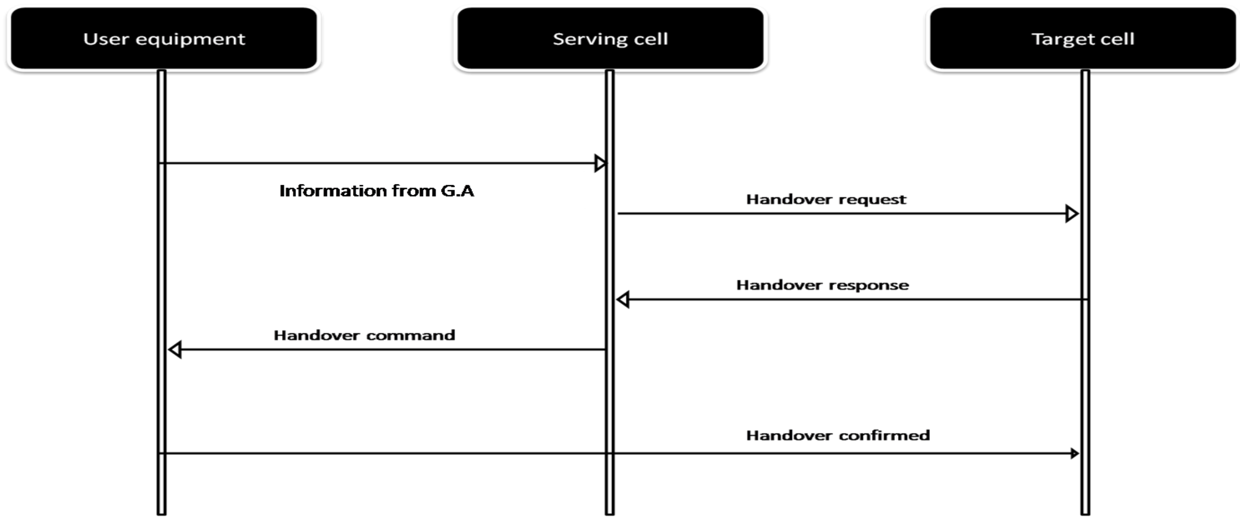

Figure 2: Model of the Handover process

VI. SIMULATION

The algorithm was implemented with communication toolbox, LTE toolbox, optimization toolbox and Simulink/Matlab. The communication and LTE toolbox were used to configure the 4G network. The optimization toolbox was configured with the G.A and then integrated on the 4G network using Matlab scripts. The simulation parameters are presented in table 1;

Table 1: Parameters for the 4G Network

Parameters	Values
Carrier frequency	2.14GHz
System bandwidth	12MHz
Standard deviation shadow fading	8Db
SINR threshold	-4.5dB
UE gain UE noise speed	560km/h
Inter site distance	500m
Noise spectral density	-174dBm/Hz
Special sub frame ratio	2/8 (1 ABS + 1 RPS)
Traffic model	Fill buffer, VOIP
Total voice packet used for the simulation	0.6mb
Channel model	Typical
	Urban
Modulation	16QAM, 64QAM, QPSK
Sub-frame duration	1s
Subcarrier number	12
Time window size	9
Frequency window size	13
Specification for VOIP	2 x 88bit

VII. RESULTS

The of the handover algorithm developed was presented after the simulation of the 4G network developed and the result presented in figure 3;

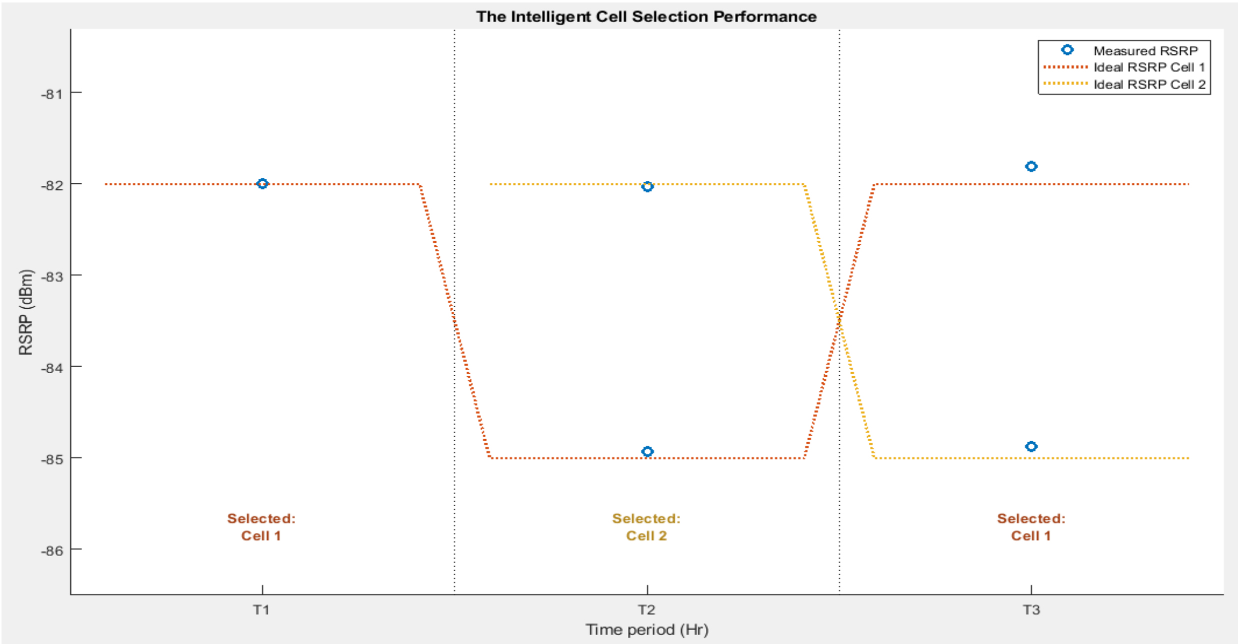

Figure 3: The performance of the G.A handover algorithm

The figure 3 presented the performance of the algorithm in the management of use equipment traveling from T1 to T3. The result showed how the RSRP of each cell was used based on the fitness computation in equation 8 to detect the time to handover to the next cell. From the result it was observed that as the user travels from T1, the cell 1 was selected to manage the carrier as having the best RSRP at the time, then the user moves to T2 and then the algorithm was able to detect poor quality of service in the UE and th3n handover to cell 2 and likewise at the T3. The implication of the result showed that the new algorithm developed was able to monitor poor quality of service as in the mobile network and then used intelligent handover decision to optimize performance.

VIII. CONCLUSION

The paper developed an intelligent handover decision algorithm for the optimization of quality of service in 4G mobile network. This was done modeling the attributes of quality of service indicators and then use the output to develop an optimization algorithm using G.A. the result when tested with simulation showed that the algorithm was able to perform handover intelligently as the user changes position and maintain quality of service.

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