International Journal of Engineering and Environmental Sciences | *ISSN 1694-4372*
Published by AIR JOURNALS | *https://airjournal.org/ijees*
16/18 Avenue des Longaniers, Quatre Bornes, Mauritius
airjournals@gmail.com; enquiry@airjournal.org

RESEARCH ARTICLE

Enhancing Mobility Management in 4g Network Using Hybrid of Mobile and Network Assisted Handoff Technique

Ogili, Solomon Nnaedozie
Department of Electrical and Electronics, Enugu State University of Science and Technology, Agbani, Enugu, Nigeria

Accepted: August 20th, 2022	Published: September 30th, 2022

Citations - APA

Ogili, S. N. (2022). Enhancing Mobility Management in 4g Network Using Hybrid of Mobile and Network Assisted Handoff Technique. *International Journal of Engineering and Environmental Sciences, 5(5), 9-18. DOI: https://doi.org/10.5281/zenodo.7820478*

ABSTRACT

This paper presents enhancement of mobility management in 4G network using hybrid of mobile and network assisted handoff technique. The aim is to address the current problem of call drop, poor service grade, and re-occurrence of handover failure which has characterized the conventional state of the art 4G network, and as a result affects quality of user experience, especially when THE user is in a mobile state. To this end, this research employed the qualitative research methodology to model a novel hybrid handover optimization algorithm, which uses cell tracking algorithm considering signal strength variable to detect weak cell and then notify the mobile assisted Handoff (MAHO) technique which employed HO information such as call drop rate, call lock probability and traffic patterns to detect the formulated problem and then initiate handover. During this process the Network Control Handover (NCHO) techniques search for cell with free channels and then recommend as the target cell for the handover execution. The model was implemented using Matlab programming code and tested with simulation. The result of the tracking algorithms showed that every cell with signal strength less than -80dB is identified as weak and recommend initiate handover. The hybrid MAHO when integrated with macro cell of HetNet and compared with standard MAHO with an average 1000 active calls attempt recorded percentage reduction is 21.5% in call drop probability.

Keywords: *Mobility Management; 4G Network; Call Drop; Network Assisted Handoff Technique*

Introduction

Over the years, the increase number of network users on daily basis has continued to trigger the need for continues upgrade of existing network infrastructures, so as to provide better management and service quality consistently. Today, most part of the world are enjoying at least the Fourth Generation (4G) network technology, which has improved user experience at low cost when compared to the conventional counterparts of 3G and others. However, certain issues such as congestion, poor handover decision making, degrade in network quality, poor bandwidth management, overload, etc., remained completely not addressed in the radio access network and core networks (Ojesanmi, *et al.,* 2022; Babatunji & Hussain, 2014).

Handover (HO) is a technique which used HO parameters and algorithms to monitor user location and ensure appropriate switching to other serving network during the mobility of users (Saddam *et al* 2022), however, in most cases, due to the dynamic nature of users in motion, the capacity of the conventional network to maintain connectivity via adaptive handoff performance has remained a very big challenge which results to mobile users experiences like frequent drop calls due to either insufficient or unavailability of channels, signal drops mostly beyond threshold frequency which brings about excessive scanning and most times frequent dropping of call either video, data and voice during handover, which may be cased as a result of interference, fading and attenuation (Saddam, *et al.,* 2022; Gongye *et al.,* 2014). Hence, there is need for an improved handover processes that will reduce complexity of scanning, low cost, sensitive to user location, with respect to the best cell around, and most importantly, provide reliable quality of service and user experience.

Over the years many literatures have tried to solve this problem of handover challenges, especially for mobile users, some of the techniques includes Liu, *et al.* (2022)'s work which employed fuzzy logic and clustering algorithm while (Gongye, *et al* 2014) used only fuzzy logic for improved HO decision making at the appropriate time. Adaptive HO algorithm was proposed for congested network management in Xianonan, Geng, & Hongyu (2020) to address the problem of latency. Kollias (2014) combined weight performance function and carrier aggregation deployment scenario, for the smart adaptation of handover control parameters, while machine learning approach was employed in Xianonan, Geng, & Hongyu (2020), using neural network algorithm for vertical HO optimization. From the literature reviewed, despite their success achieved so far, quality of service achieved has not been replicated the same success in user experience and this has remained a gap. The aim of this paper is to enhance mobility management in 4G network using an Adaptive Mobile-Network Assisted Handoff Technique (h-MAHO). This when achieved will ensure that some issues which might impede seamless communications if overlooked from the onset like the network characterization and the handoff process will be addressed.

Literature Review

Omitola (2020) proposed a channel borrowing admission control scheme for enhanced call admission control (CAC) during handover process between two-tier HetNet. The scheme was also improved with mobile relay nodes for handover preparation and then applied to a fast-moving vehicle. The result showed significant reduction in call drop rate and HO failures. Muhammad et al (2022) Proposed Software Defined Network (SDN) which monitors the performance of HO parameters and control entry flow into switches. The result when tested between two EnodeB, showed a 5.125kbps net increase in speed during HO, which is better than Muhammad et al. (2022).

Centralized mobility management which is characterized by single point failure during HO of LTE was addressed by Battulga et *al* (2017) using Distributed Mobility Management (DMM) strategy and SDN. The approach was defining the HO processed with data buffering, forward processing between nodes, and mobility anchors. The result when tested over cell distance of 0.5km to 2km, achieved better performance than the conventional systems DMM.

Emran and Kotuliak, (2020) presented a new HO approach which combined h-MAHO and Guard Channel (GC) that allows feedback information of free channels, signal strength information and bit error rate. The h-MAHO and GC considers both signal quality and free channel to ensure that HO is effective and also user experiences reduced call drop. In the same vein (Madan, Dharmaraja, and Trivedi 2008), presented a review on the state-of-the-art HO optimization algorithms, considering both vertical and horizontal types respectively. The study exposes critical HO parameters which are vital for HO configuration in wireless network. Furthermore, Azeddine *et al* (2016) and Jeremiah *et al* (2017) presented a review on the existing HO methods and revealed that quality of service is defined as speed and success of HO. The study in addition recommended soft computing-based approach for HO; however, the result recorded for SDN in Battulga (2017) may not reveal that the approach is the best, as it experiences initial delay and also the routing speed can be optimized as reported in Battulga (2017).

Phemina *et al* (2016) and Ozlowska (2007) took into considering signal strength, bandwidth, cost, user preference and velocity as input attributes to a fully engine for HO decision optimization. The author recommended that more input to the controller laws will result to better HO decision. In Phemina *et al* (2016), HO scheme was developed considering load, strength of signal and mobile terminal and achieved improved Ho performance, while Prince (2016) use session initialization protocol with cross layer scheme to address resetting problem in LTE.

Methodology

1n this work a lot of related literatures on the mobility managements in mobi1e networks especially on 4G networks and adaptive mobile network assisted and unassisted handoff were reviewed. The identified research gap which is quality of user experience was addressed by developing a hybrid HO optimization model which used tracking algorithm to monitor the problem formulation in the cell and then MAHO to prepare the HO process by collecting the number of cells within the HetNet and then select the best using signal strength information inspired From the NCC standard for 4G LTE and then employed the NCHO for the selection of free channel for the HO process. This model was implemented with Matlab and tested in a three tier HetNet.

Methodology

1n this work a lot of related literatures on the mobility managements in mobi1e networks especially on 4G networks and adaptive mobile network assisted and unassisted handoff were reviewed. The identified research gap which is quality of user experience was addressed by developing a hybrid HO optimization model which used tracking algorithm to monitor the problem formulation in the cell and then MAHO to prepare the HO process by collecting the number of cells within the HetNet and then select the best using signal strength information inspired From the NCC standard for 4G LTE and then employed the NCHO for the selection of free channel for the HO process. This model was implemented with Matlab and tested in a three tier HetNet.

Development of Algorithm for Signal Tracking and Channel Acquisition for Handoff

1. *Start*
2. *Initialization of 4G network parameters*
3. *Activate time control function (t)*
4. *Set delay 50ms*
5. *Search for available signal and quality strength*
6. *If*
7. *Cell is active with user*
8. *Check signal strength*
9. *Else If*
10. *Signal strength is < or = -80dB = true*
11. *Hand off*
12. *Else*
13. *Proceed with roaming*
14. *End if*
15. *If*
16. *Idle cell channel is visible*

International Journal of Engineering and Environmental Sciences | IJEES
Vol. 5, No. 5 | 2022 | pp. 9-18 | DOI: https://doi.org/10.5281/zenodo.7820478

17. *Return to step (11)*
18. *Else*
19. *Return to step (13, 14, 14)*
20. *Do until step (11) is successful*
21. *Return to step 1*
22. *End if; end if; end if*
23. *End*

Modeling of hybrid Handoff system

The hybrid HO model was developed using Mobile Adaptive Handoff (MAHO) and Network Coordinated Handoff (NCHO) techniques. The approach was inspired from the work of (Muhammad 2022) which used h-MAHO and GC for HO optimization considering free channel, bit error rate and signal strength. This work took a better approach which considers key attributes of HO information such as drop call probability, call arrival rate and traffic density to determine the condition of the cell and initiate handover when weak signal strength which indicated poor quality of service is detected. The basic hybrid handover model was presented in figure 1;

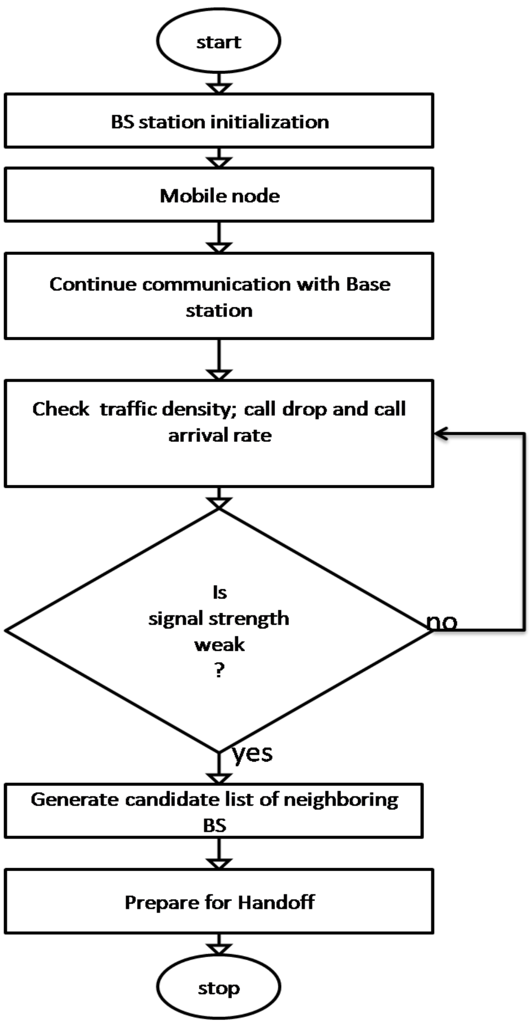

Figure 1: Mobile Adaptive Handoff

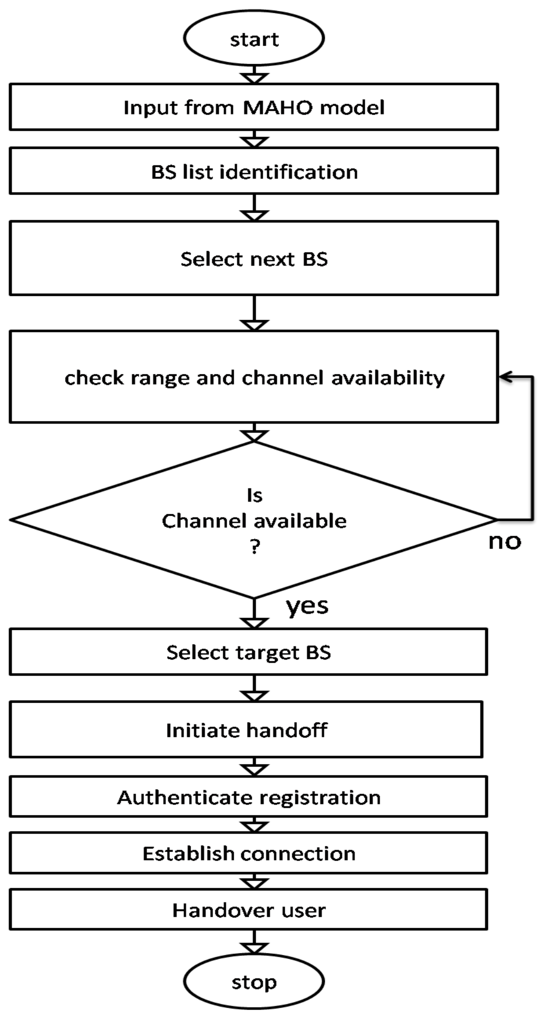

Figure 2: Network Coordinated Handoff

The figure 1 presented the MAHO handover model which is used for the optimization of handoff process. The flow chart showed how the base station (BS) initiates call as the mobile user changes position rapidly inside a vehicle. The BS used the call arrival rate, call drop probability and traffic density to determine the strength of the BS. Equation 1 presents the call blocking probability, while the drop call rate is presented with equation 2;

$$P_b = \frac{p^c}{c!} P_o \quad (1)$$

$$P_d = \frac{c!}{(c+k)!} (p)^k \frac{p^c}{c!} P_o \quad (2)$$

Where, $P_o = \left[\sum_{i=0}^{c} \frac{p^i}{l!} + \sum_{n=1}^{k} \frac{c!}{(c+n)!} (p)^n \frac{p^c}{c!}\right]$ (3)

ρ = l/m - traffic intensity for both fresh and handover calls; ρ¢ = l¢/m - traffic intensity of only handover calls; µn =service rate 0f new calls; µh =service rate of handoff calls. The figure 2 on the other hand is the NCHO which adaptive select the best cell for the HO process using signal strength information. The figure 3 presents the adaptive MAHO model which combined the signal tracking algorithm, MAHO and NCHO for optimal HO coordination and control.

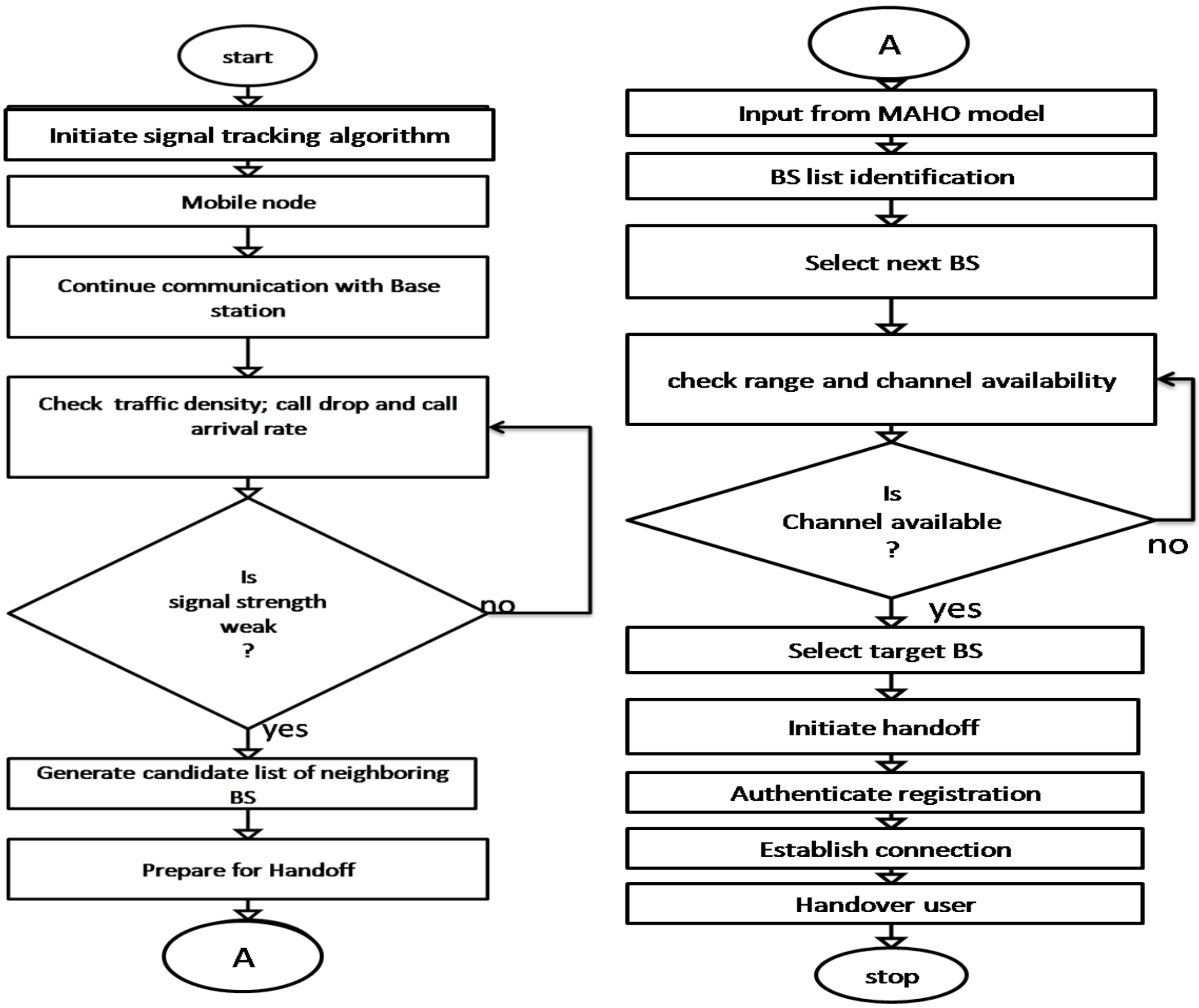

Figure 3: Flow chart of the hybrid model of MAHO and NCHO

The hybrid MAHO model which was used for the HO optimization in 4G LTE is presented in figure 3. The tracking algorithm was used for the monitoring of the cell status considering signal strength as the key attributes. When the signal is less then -80dB, the weak cell performance is predicted and then activate the MAHO which considered other cell information such as call drop, call arrival rate and call traffic to conform the congestion problem, before initiate the HO process preparation by selecting available cell within the area, the then NCHO was used to search and identity cell with free channel, which is now engaged for the communication process.

Simulation and Results

The models and algorithm developed was simulated using communication toolbox, signal processing toolbox, LTE-A toolbox and Matlab programming environment. The performance of the model was evaluated considering the Nigerian Communication Commission (NCC) standard for HO performance in 4G LTE. The wireless network under study is a multi-tier HetNet comprising of macro, pico and micro cells, configured using the parameters in table 1;

Table 1: Simulation parameters

Cell layout	*Hexagonal grid, 3 sector per site*	*1 Pico per site*	*1 Micro per site*
Carrier frequency	2.1GHz	4.51GHz	4.50GHz
Bandwidth	10.0MHz	100.0MHz	50.0MHz
Cell radius	289.0m (500m)	-	-
Transmitting Antenna height	32.0m	10.0m	15.0m
Transmitting antenna power	14.1dBi	4.0dBi	7.0dBi
User equipment distribution	15.1deg	10.0deg	10.0deg
Scheduling algorithm	30UE per sector, 2/3 clustered distribution		
Link adaptation	QPSK TO 1024-QAM (25 MCS indexes)		
Traffic model	Full buffer		
MIMO	3*2SU-MIMO		

Results And Discussions

This section presented the results of the simulation algorithm and model on the HetNet. The result tested the Ho tracking algorithm developed which used signal strength to monitor and determine the time of HO as shown in the table 2.

Table 2: Result of the cell Tracking Algorithm

Time (Hrs)	*Hand over call attempt*	*Rx Signal Strength (dB)*	*Failure*	*Successful*
0600-0630	124	-63.9	14	110
0631-0700	130	-66.8	14	116
0701-0730	125	-73.5	12	113
0731-0800	185	-75.3	18	167
0831-0900	200	-95.8	15	185
0901-0930	195	-98.8	10	181
0931-1000	180	-99.2	10	157
1031-1100	179	-70.0	18	161
1101-1200	165	-105.5	5	154
1201-1230	160	-98.8	12	148
1231-1300	150	-99.3	11	139
1301-1330	145	-70.0	15	130
1331-1400	140	-100.8	8	130
1401-1430	143	-97.8	11	132
1401-1430	142	-65.3	16	126
1431-1500	150	-99.9	8	139
1501-1530	160	-101.9	5	149

1531-1600	175	-56.5	22	153
1601-1630	205	-100.9	5	190
1631-1700	202	-50.2	29	173
1701-1730	190	-55.8	25	165
1731-1800	125	-72.8	12	113
Average	162.2727		13.40909	146.8636

The result of the tracking algorithm developed for the monitoring of the cell performance considering signal strength values at each time stamp is shown in table 1. The result showed that on the average, beyond 163 HO attempts which were initiated when the signal strength falls below -80dB, 147 were successful, while 13.4 were unsuccessful. The implication of the result is that 90.18% of the HO process was successful, which means that the tracking algorithm was able to detect with high accuracy the condition for the cell HO. The graphical analysis was presented in figure 4;

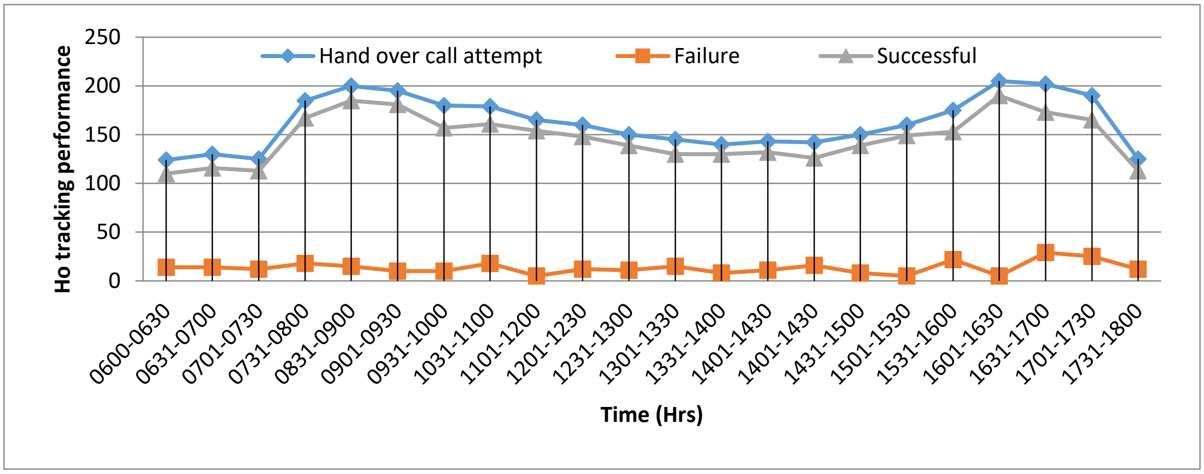

Figure 4: Graph of the tracking algorithm performance

From the graph, it can be observed that the successful HO closely follows the HO call attempt. What this means is that the tracking algorithm successfully detect the cell condition required for HO correctly. Having evaluated the tracking algorithm, it was used to develop the hybrid MAHO and evaluated as shown in table 3;

Table 3: Hybrid MAHO Handoff result

Serving BS	**Target BS**	**No. of HO**	**RSS (dbm)**	**% Outage**
BS1	Micro BS	8.2	-65.5	0.63
BS1	Pico BS	9.55	-66.45	0.70
BS1	Micro BS	10.15	-65.9	0.65
BS1	Pico BS	10.35	-66.15	0.68
BS1	Pico BS	10	-65.4	0.62
BS1	Micro BS	9.7	-64.0	0.50

Table 3 presents the hybrid MAHO which used HO information as modeled in figure 4 to detect problem of poor quality of service in the serving cell and then select the best neighboring cell with free channel for the HO process. From the result of table 3, it was observed that the signal strength of the macro cell was less than -80dB. This means that the hybrid MAHO was able to address the problem of user mobility as the signal strength was maintained to standard requirement for NCC.

The hybrid model was integrated on a macro cell and tested with multiple numbers of users as presented in table 4;

Table 4: Integration of Hybrid MAHO against standard MAHO

Offered calls	***Probability of call blocking % without Hybrid MAHO***	***Probability of call blocking % with Hybrid of MAHO***
100	0.0136	0.0000
200	0.1597	0.0000
300	0.3383	0.0003
400	0.4695	0.0016
500	0.5611	0.0055
600	0.6270	0.0136
700	0.6762	0.0270
800	0.7141	0.0461
900	0.7442	0.0700
1000	0.7686	0.0978
1100	0.7888	0.1281
1200	0.8058	0.1597
1300	0.8203	0.1916
1400	0.8328	0.2232
1500	0.8436	0.2539
1600	0.8532	0.2834
1700	0.8616	0.3116
1800	0.8691	0.3383
1900	0.8759	0.3636
2000	0.8820	0.3874
Average	0.67527	0.145135

The table 4 presents the performance of the hybrid MAHO after integration on the macro cell. The result after evaluation with probability of call drop and the result achieved with an average of 1000 calls attempt is 0.67527% and when compared with the standard MAHO is 0.14514% and the percentage reduction is 21.5%. The graphical analysis of the result is presented in figure 5;

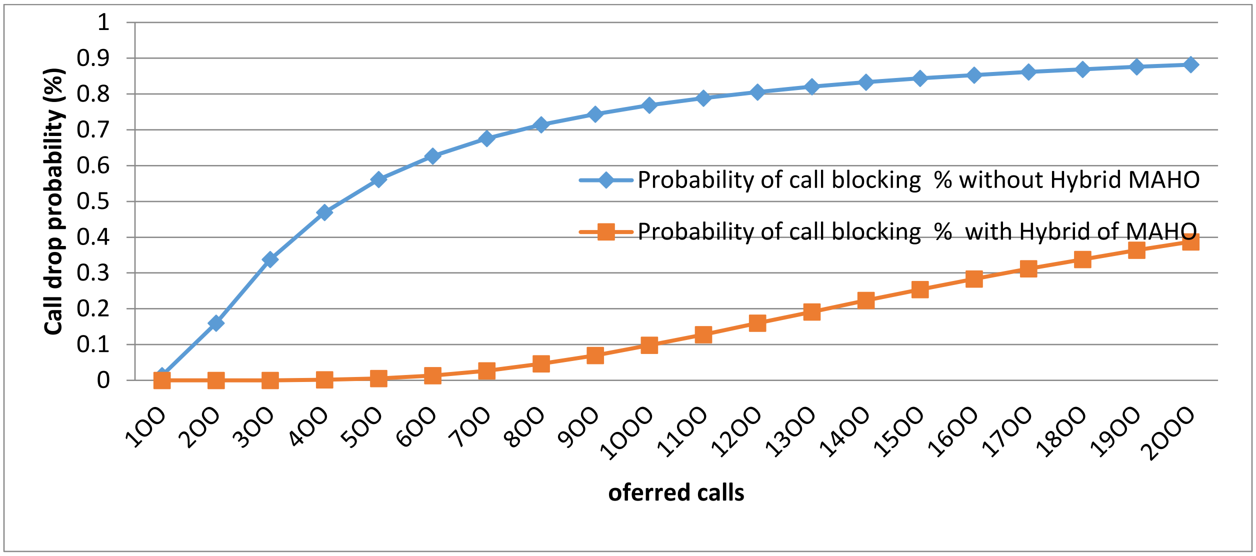

Figure 5: Comparative performance of call blocking with and without the hybrid MAHO

The figure 5 presents the comparative analysis of the hybrid MAHO and without MAHO, considering probability of call failure. The result showed that the probability of drop call with the hybrid MAHO is lower than that without hybrid MAHO.

Conclusion

Over the years the impact of user mobility on the quality of HO performance has remained a research area which requires urgent attention. Despite the success of existing techniques presented in the review of literatures, solutions were not obtained which can replicate the same quality of service success for user experience. This research presented a hybrid solution to the problem using a tracking algorithm, MAHO and NCHO model to develop a HO optimization system which considers key HO information such as call drop rate, probability of call block, traffic load, and signal strength to monitor, detect poor quality of service in a congested cell and the search for free channels for successful HO.

Reference

Ojesanmi O. A., Vincent O., Kassim M., & Osinuga O. (2022). A mobility aware handover scheme for LTE System. *NIJITECH* 41(6), 980-989.

Babatunji, O. & Hussain, R. (2014). Dwell time prediction model for minimizing unnecessary handover in Hetnet considering Amoebic shaped coverage region 1412-2181

Saddam, A.; Rosdiadee, N.; Ibraheem, S.; Nor, F. A.; Asma, A., and Abdulraqeb, A. (2022). Effectiveness of Handover Control Parameters on Handover Performance in 5G and beyond Mobile Networks. *Hindawi Wireless Communications and Mobile Computing*, 18 pages

Battulga, D., Ankhzaya, J., Ankhbayar, B., Ganbayar, U., and Sodbileg, S. H. (2017). Handover management for distributed mobility management in SDN-based mobile networks. 27th International Telecommunication Networks and Applications Conference (ITNAC); pp. 1-6.

Emran M. & Kotuliak, I. (2020). Performance analysis of traditional and SDN based handovers in wireless LAN networks in *2020 IEEE International IOT, Electronics and Mechatronics Conference (IEMTRONICS),* pp. 1–6, IEEE, Vancouver, BC, Canada, 2020

Gongye, R. Q., Hua Q., & Zhao, J. (2014). Hnaodver decision making algorithm or vertical handover based on multi terminal cooperation based fuzzy logic. *J. Commun* 5(9), 67-78.

Jeremiah O., Abolade, O., Fakolujo A, & Abidemi O. (2017). Handover in Mobile Wireless Communication Network - A Review. *International Journal of Advanced Engineering, Management and Science (IJAEMS), 3(9) 1-7*

Kollias, G; Adelantado F; Vardakas, J. and Ramantas, K. (2014). Handover performance in LTE-A HetNets through intersite distance differentiation, in 2014 IEEE 19th International Workshop on Computer Aided Modeling and Design of Communication Links and Networks (CAMAD), pp. 280–284, Athens, Greece, 2014

Liu, Q., Kwong, C. F., Zhang, S., Li, L. and Wang, J. (2022). A fuzzy clustering-based approach for MADM handover in 5G ultradense networks. *Wireless Networks,* 1–14, 2022, https:// link.springer.com/article/10.1007/s11276-019-02130-3.

Madan, B., Dharmaraja, S. and Trivedi, K. S. (2008). Combined Guard Channel and Mobile-Assisted Handoff for Cellular Networks. *IEEE Transactions on Vehicular Technology,* 57(1), 502-509.

Muhammad E, Vijey T, Muhammad U, Ivan K, Muhammad S. Q, & Muhammad B, Q. (2022). The Handover and Performance Analysis of LTE Network with Traditional and SDN Approaches. *Hindawi Wireless Communications and Mobile Computing*, 1-9.

Ojesanmi O. A., Vincent O., Kassim M., & Osinuga O. (2022). A mobility aware handover scheme for LTE System. *NIJITECH*, 41(6), 980-989.

Omitola O. (2020). Hanodver management streategies in LTE-A. Thesis; Research space; university of Kwazulu-Natal. http://researchspace.ukzn.za/handles/10413/18855.

Ozlowska, E. (2007). Optimization of Handover Mechanism in 802.16e using fuzzy logic. In B. Simak R. Bestak & R. Kozowska (Eds.), IFIP International Federation for Information Processing (Vol. 245, pp.115-122). Personal Wireless Communications Boston: Springer.

Phemina M., S. and Sendhilnathan. S. (2016). Fuzzy Based Mobility Management in 4G Wireless Networks. *Brazilian Archives of Biology and Technology, An International Journal*, 59:e16161047, http://dx.doi.org/10.1590/1678-43 24- 2016161047

Prince E. E, (2016). A Novel Seamless Handover Scheme for WiMAX/LTE Heterogeneous Networks, Arab Journal of Science and Engineering, 41:1129- 1143, DOI 10.1007/s13369-015-1984-3

Saddam A, Rosdiadee N., Ibraheem S., Fadzilah, A., Abu-Samah, A, and Abdulraqeb, A. (2022). Effectiveness of Handover Control Parameters on Handover Performance in 5G and beyond Mobile Networks. *Hindawi Wireless Communications and Mobile Computing*

Xianonan T., Geng C., and Hongyu S. (2020). Vertical handover algorithm based on multi attribute and neural network in HetNet integrated network. *EURASIP Journal on wireless communication and networking*; 202, 1-18.