Adaptive handover control parameters based on cell load capacity in a B5G/6G heterogeneous network

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ABSTRACT

In the B5G/6G network, the deployment of small cells increased to keep up with the growth of mobile traffic. This deployment will increase the number of handovers (HOs) between cells. Ping-pong handover (PPHO) and radio link failure (RLF) are considered the two major problems in HO that may occur. So, the challenge is to set the handover control parameters (HCPs) carefully to find out the proper HO decision that should be appropriate to the environmental constraints. Therefore, in our paper, we propose an adaptive HCPs algorithm that adapts to environmental constraints. In addition, the proposed algorithm will have immunity to RLF and will significantly minimize the amount of PPHO compared to other workers. In the simulation results, our proposed model is evaluated using two frequency plans. By using frequency plan 1, the user mean throughput increased from 270 Kbps to 281 Kbps when the serving cell was fully loaded. By using frequency plan 2, the user mean throughput increased from 6 Mbps to 20 Mbps when the serving cell was fully loaded. In addition, the amount of ping-pong handover between overlapped small cells decreased and will not exceed one PPHO compared to another literature model.

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1. INTRODUCTION

By the year 2026, it is expected that the global traffic in mobile data will reach 220.8 million terabytes per month [1]. Traditionally, from 80% to 90% of mobile data traffic is generated indoors [2], [3]. The deployment of femtocells is one of the successful solutions that can deal with this huge indoor data traffic. Femtocells, also called home base stations [4], can offload network traffic using energy-efficient power consumption [5]. Ultra-dense networks (UDNs) in B5G/6G need a high number of small cells (i.e., femtocells). The forecast expectation for femtocell marketing is going to increase during the period 2022–2030 [6]. In femto network density, especially in open access mode, as the number of deployed femtocells increased, handover (HO) increased. Actually, two major problems may have occurred relative to the HO decisions, which are ping-pong handover (PPHO) and radio link failure (RLF). PPHO is generated when the distance is small between neighboring cells; thus, the user equipment (UE) will oscillate between the cells. The efficient HO decision should be based on decreasing the probability of PPHO occurring, a high number of PPHO, high network signal overhead, bad resource utilization, and low network throughput. RLF occurs either when degradation happens in the signal-to-interference plus noise ratio (SINR) between serving and target cells before the HO procedures are completed or when the target cell has insufficient resources. Therefore, these problems can be avoided when we carefully select the handover control parameters (HCPs) and find the proper target cell.

Handover margin (HM) and time to trigger (TTT) are the two main HCPs. where HM is the minimum difference between the received signal power of the serving cell and that of the target cell. To initiate an HO process, the reference signal received power (RSRP) of the target cell should be greater than the RSRP of the serving cell by an HM level. HM values vary between 0 and 30 dB, with an interval of 1 dB between each step [7]. TTT is the time interval taken to track the RSRP of the target cell before executing the HO decision. TTT intervals are standard by the 3rd generation partnership project (3GPP) as follows: {0, 40, 64, 80, 100, 128, 160, 256, 320, 480, 512, 640, 1024, 1280, 2560, and 5120 ms}[7]. The execution of HO is considered a solution for cell load balance. Performing this balancing will enhance the overall network throughput.

Wu *et al.* [8] proposed HO algorithms considering the user velocity and the received signal strength but the proposed algorithms not depended on the HCPs. Alhabo and Zhang [9] used fixed-setting HCP values that varied with the UE speed to perform cell load balance. The HO's decision was to rely on the serving cell load percentage to offload the congested cell. Hence, increase the network throughput. Alraih *et al.* [10] used various setting HCPs in the B5G network and evaluated the RSRP, HO probability (HOP), PPHO rate, and the RLF rate to find out the best setting HCPs in different environmental scenarios. Kabiri *et al.* [11] proposed a HO algorithm in a heterogeneous network including all macro, micro, pico, and femtocells to select the target base station (BS). The HO algorithm is based on predicting the received signal strength (RSS) and estimating the future SINR values of the candidate target cells to reduce the number of HOs and PPHOs and get higher throughput. Rajabizadeh [12] calculates the time of stay (TOS) for the UE in the cell to choose the proper target cell between overlapped small cells, taking into account the UE speed value. Unlike in the past, the author discovered that HO to a small cell located far away from the UE allows the UE to stay connected to the cell for a longer period of time, allowing unnecessary HO to be avoided. Yusof *et al.* [13] suggested a HO load balancing strategy for HetNet. When the small cell (SC)'s capacity is available and the UEs' speed is low, the UEs are compelled to execute the HO to the SC. To reduce the HO failure, these UEs are also allowed to establish a temporary connection to the macrocell in the event that the SC's capacity is insufficient. Fast moving UEs, on the other hand, are linked to macrocell. Nevertheless, this approach is ineffective when used in a dense SC HetNet, as this could lead to a needless HOs, and signal overhead.

The above workers used fixed-setting HM and TTT values in their estimations. However, Cho *et al.* [14] proposed a handover technique to treat train speed (350 Km/h) using an adaptive TTT parameter to reduce the failure HO and the unnecessary HO. The adaptive TTT based on the train velocity against the difference between the distance when the RSRP of serving BS is below a defined threshold (i.e., an LTE A2 event) and when the RSRP of serving BS reaches the RLF. But the HM parameter is not studied in this paper. Alhammadi *et al.* [15] a self-optimization algorithm to adjust the HCPs in a 4G/5G heterogeneous network. The author utilizes the RSRP and UE speed to adjust both HM and TTT during UE movement, where the standard values for both HM and TTT are put in the form of level steps. Then, the self-algorithm increased or decreased the level steps based on the current RSRP and the UE speed. Abdulraqeb *et al.* [16] classifies HO failure into three types: too late, too early, and wrong cell HO. A dynamic HCP algorithm is proposed to adjust the HCPs. When a too late Ho is detected, low values of HCPs are assigned, and when a too early Ho is detected, high values of HCPs are assigned. The auto-tuning adjustment for HCPs in [15], [16] was done without sufficient proof. Karmakar *et al.* [17] adapts the TTT and the HM values based only on predicting the serving cell's and its neighbors' future signal quality. Achhab *et al.* [18] proposed adaptive HCPs in LTE-A heterogeneous networks that adapt with RSRP, SINR, and UE velocity. The author performed a mathematical expression to find out the proper HM level and also found a relationship between HM level, TTT value, and UE velocity. However, the author doesn't consider the status of cell load capacity and doesn't utilize the HCPs to balance the load between the network cells. Therefore, our contribution to this paper can be summarized as follows:

- An adaptive HCPs algorithm is proposed based on a combination of all network constraints such as RSRP, SINR, cell load capacity, ToS of UE in a cell, and UE velocity.
- The proposed algorithm induces the proper HO decision that creates balance between cells in a B5G/6G heterogeneous network.
- We minimize the candidate neighbor cell list to get faster HO and lower signal overhead. In order to add the candidate cell to the list, it must meet some restrictions.
- The algorithm provides early HO decisions for UEs that access congested cells. Thus, UE mean throughput will be improved.
- Different frequency plans are implemented to evaluate our proposed system model.

The paper is organized as follows: section 2 describes the proposed system model. Section 3 provides the simulation parameters, results, and discussions. Finally, conclusions are drawn in section 4.

2. METHOD

A two-tier B5G/6G heterogeneous network is considered to be composed of a macrocell (m) and multiple numbers of femtocells (N^f), as illustrated in Figure 1. The macrocell serves a number of macrocell users (MUEs), which are indexed by *mue*=1, 2, 3…, N^m_{mue}. Each femtocell (*f*) may be a serving cell (*i*) or a target cell (*j*). Serving femtocell (*fi*) serves a number of femto-users (FUEs), which are indexed by *fuei*=1, 2, 3 …,$N^{fi}_{fue_i}$. The target femtocell (*fj*) serves FUEs, which are indexed by *fuej*=1, 2, 3…,$N^{fj}_{fue_j}$. The femtocells are distributed randomly, and the coverage ranges of all femtocells are similar. When the serving cell (i.e., macrocell or femtocell) becomes loaded, a poor quality of service (QoS) is delivered to the user (i.e., MUE or FUE). This phenomenon will lead to the occurrence of a radio link failure (RLF) and reduce the network throughput. So, for congested cells, early handover (HO) is the proper decision. Therefore, we can conclude that the handover decision should be based on the cell load. Table 1 shows the definitions of the symbols that are used throughout the course of this paper.

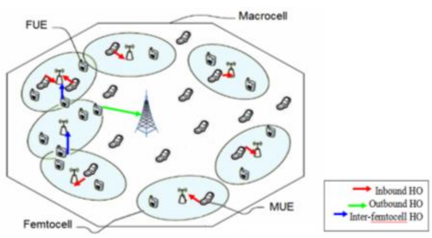

Figure 1. Different handover categories in a two-tier heterogeneous network

Table 1. Definition of symbols

Symbol	Definition
m	macrocell index
mue	macro-user index
fi	serving femtocell index
fue_i	index of FUEs in a serving femtocell
fj	target femtocell index
fue_j	index of FUEs in a target femtocell
N^f	the total number of femtocells in a macrocell
N^m_{mue}	the total number of MUEs in a macrocell
$N^{fi}_{fue_i}$	the total number of FUEs in a serving femtocell
$N^{fj}_{fue_j}$	the total number of FUEs in a target femtocell
L_m	the load on the macrocell
L_{fi}	the load on a serving femtocell
L_{fj}	the load on a target femtocell
bw^m_{mue}	the required bandwidth for a MUE
$bw^{fi}_{fue_i}$	the required bandwidth for a FUE in a target femtocell
$bw^{fj}_{fue_j}$	the required bandwidth for a FUE in a target femtocell
W_m	the available bandwidth for the serving macrocell
W_{fi}	the available bandwidth for the serving femtocell
W_{fj}	the available bandwidth for the target femtocell
R^m_{mue}	the demand data rate of a MUE
$R^{fi}_{fue_i}$	the demand data rate of a FUE in a serving femtocell
γ^m_{mue}	the SINR received from the macrocell at a MUE
$\gamma^{fi}_{fue_i}$	the SINR received from a serving femtocell at a fue_i
γ^{fj}_{mue,fue_i}	the SINR received from a target femtocell at *mue or* fue_i
$\gamma^{rfj}_{mue}(t)$	the instantaneous SINR received from a target femtocell at *mue*
$\gamma^{rfj}_{fue_i}(t)$	the instantaneous SINR received from a target femto-cell at fue_i
$RSRP_m$	reference signal received power from the macrocell
$RSRP_{fj}$	reference signal received power from a target-femto
$RSRP_{fi}$	reference signal received power from a serving-femto
σ	the thermal noise power
θ	the SINR threshold
ToS^{fj}_{mue,fue_i}	the time of stay for *mue or* fue_i in a target femtocell
R^{fj}	the radius of the target femtocell
V_{mue,fue_i}	the UE velocity (i.e., MUE or FUE)
T_{th}	minimum allowable time to stay

2.1. Estimation of cell load based on different handover categories

In Figure 1, there are three categories of HO that may occur. Inbound HO occurs when a MUE hands over from a macrocell to a femtocell, while outbound HO occurs when the FUE hands over from a femtocell to a macrocell. Also, the inter-femtocell HO occurs when the FUE hands over between two femtocells. The selection criteria for choosing the target femtocell are the most challenging task based on different HO categories. In outbound HO, the target cell is the macrocell. Therefore, in our paper, we will focus on both the inbound and inter-femtocell HO categories.

2.1.1. Inbound handover category

The load on the macrocell can be calculated as in [19], [20]:

$$L_m = \frac{bw_{mue}^{m} . N_{mue}^{m}}{W_m} \tag{1}$$

The required bandwidth for each MUE can be expressed as:

$$bw_{mue}^{m} = \frac{R_{mue}^{m}}{log_2(1+\gamma_{mue}^{m})} \tag{2}$$

where it depends on the demand data rate of a MUE and the SINR received from the macrocell at a MUE. This received SINR is the ratio of the received power from the macrocell to the sum of the interference power of all femtocells in the whole of the macrocell plus the thermal noise power.

$$\gamma_{mue}^{m} = \frac{RSRP_m}{\sum_{j=1}^{Nf} RSRP_{fj} + \sigma^2} \tag{3}$$

2.1.2. Inter-femtocell handover category

The load on a femtocell can be calculated as in [19], [20]:

$$L_{fi} = \frac{bw_{fue_i}^{fi} . N_{fue_i}^{fi}}{W_{fi}} \tag{4}$$

The required bandwidth for each FUE can be expressed as:

$$bw_{fue_i}^{fi} = \frac{R_{fue_i}^{fi}}{log_2(1+\gamma_{fue_i}^{fi})} \tag{5}$$

where it depends on the demand data rate of a FUE and the SINR received from a femtocell at a FUE. This received SINR is the ratio of the received power from the femtocell to the sum of the interference power of all other cells, including the macrocell, plus the thermal noise power.

$$\gamma_{fue_i}^{fi} = \frac{RSRP_{fi}}{RSRP_m + \sum_{j=1 j\neq i}^{Nf} RSRP_{fj} + \sigma^2} \tag{6}$$

2.2. Choosing the target cell based on Adaptive Handover Control Parameters (AHCPs)

Previous works, as in [10], [21], [22] choose the target cell based on the reference signal received power of the serving cell and the handover control parameters (HCPs), i.e., handover margin (HM) and time to trigger (TTT), that are presented in (7):

$$RSRP^{target}(t) \geq RSRP^{serving}(t) + HM; ForTTT\_durationtime \tag{7}$$

Achhab *et al*. [18] found a direct relationship between the HM and the TTT that made a perfect balance to avoid PPHO and RLF HO problems. Furthermore, the author adapted the handover control parameters to several network factors rather than the traditional fixed setting. The estimation of the adaptive HM that is described in [18] is based on the RSRPs of both the serving cell (i.e., macrocell or femtocell) and the target cell (i.e., femtocell) under the condition that the SINRs of the user with regard to both the serving and the target cells are good (i.e., a predefined SINR threshold). So, the signal link between the user and the cells will not be lost.

On the other side, the estimation of the adaptive TTT is based on the corresponding values of the adaptive HM and the moving user velocity. Figure 2 represents the HO decision based on AHCPs.

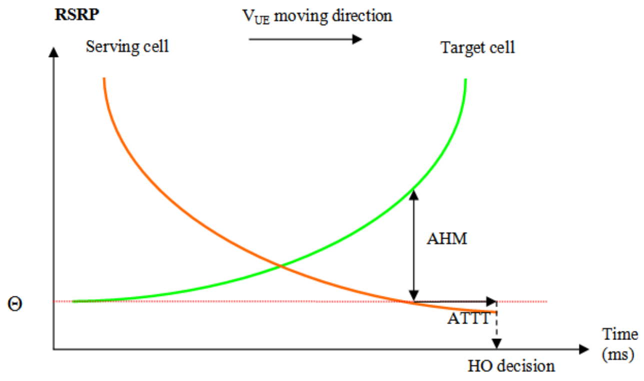

Figure 2. HO decision based on AHCPs [18]

2.3. Choosing the target cell based on the proposed adaptive handover control parameters and cell loading

In the proposed adaptive handover control parameters and cell loading (AHCPs-CL), we will include the load factor among the network factors that affect the HCPs. In practice, heavy load on the serving cell delivers poor quality of service (QoS) to the user, which reduces the network throughput and leads to the occurrence of the RLF. So, for congested cells, early HO is the proper decision. Therefore, in our proposal, we will consider a combination of the cell load, SINR, RSRP, and UE velocity to find the proper adaptive HCPs. Therefore, we can make an HO decision under the precision factors that include all the network constraints to eliminate the HO problems. Figure 3 represents the proposed HO decision based on AHCPs-CL.

Frequently unnecessary HO is one of the HO problems that happen in femtocells. Because of UE speed, UE can enter and leave the femtocell before taking a service. Therefore, the time of stay (ToS) for a UE in a femtocell should be greater than the short time of stay threshold that is defined in [9]:

$$ToS^{fj}_{mue,fue_i} = \frac{4R^{fj}}{\pi V_{mue,fue_i}} > T_{th} \tag{8}$$

The neighbor candidate list (NCL) is the list of cells from which UE can select the target cell to handover. Choosing the NCL will be based on:

a. $ToS^{fj}_{mue,fue_i} > T_{th}$, to avoid unnecessary HO [9].

b. $L_{fj} = \frac{bw^{fj}_{fue_j} . N^{fj}_{fue_j}}{W_{fj}} < 1$, to ensure the existence of radio resources [19].

c. $\gamma^{\;fj}_{mue,fue_i} = \frac{RSRP_{fj}}{RSRP_m + \sum_{i=1 i\neq j}^{N^f} RSRP_{fi} + \sigma^2} > \theta$, to guarantee a good QoS for UE [18].

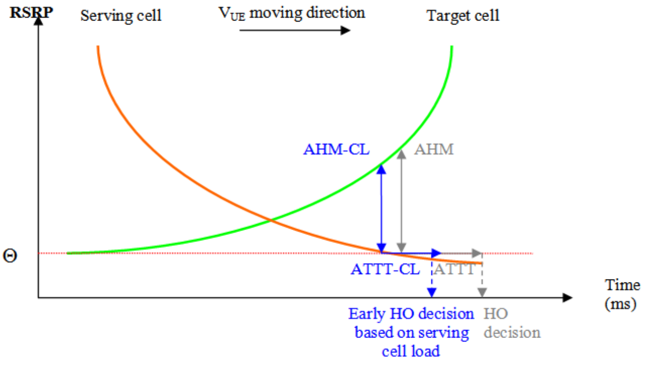

Figure 3. Proposed handover decision based on AHCPs-CL

The proposed AHCPs-CL is composed of an adaptive HO margin based on cell load (AHM-CL) and an adaptive time to trigger based on cell load (ATTT-CL). Therefore, the proposed AHCPs-CL algorithm will be implemented as follows:

a. For the inbound HO category, the AHM-CL is calculated through three cascade stages. First, we compute the adaptive HM (AHM) based on the RSRPs of both the serving macrocell and the target femtocell [18]. These calculations are taken under the condition that: a) the SINR of the user with regard to the serving macrocell is good (i.e., greater than or equal to a predefined threshold) to avoid the RLF and b) the SINR of the user with regard to the target femtocell is greater than the SINR of the serving macrocell to force the MUE to offload from the congested macrocell.

$$AHM = \max\left\{0, HM_{\max}\left(1-\left(\frac{RSRP_m}{RSRP_{fj}}\right)^2\right)\right\}$$

$$subject\_to\begin{cases}\gamma^{m}_{mue}(t) \geq \theta \\ \gamma^{fj}_{mue}(t) > \gamma^{m}_{mue}(t)\end{cases} \tag{9}$$

To find out the SINR of the required target cell, inspired by (7), Alhabo and Zhang [9] considered the SINR instead of the RSRP and made the choice of the SINR of the target cell based on the serving cell load using a fixed HM setting. Therefore, in our second stage, we will compute the required SINR of the target femtocell that will be based on the congested macrocell load, which according to [9] can be written as:

$$\gamma^{rfj}_{mue}(t) \geq \gamma^{fj}_{mue}(t) - (L_m.AHM) \tag{10}$$

From (10) choosing the target SINR will be decreased based on the serving cell load. So, in a congested serving cell, an early HO decision will take place at a higher serving SINR. Therefore, UE can perform the HO between the two cells with higher throughput.

Finally, the AHM-CL is computed based on the RSRPs for both the serving macrocell and the target femtocell under the condition that: a) the SINR of the user with regard to the serving macrocell is good (i.e., greater than or equal to a predefined threshold) and b) the SINR of the user with regard to the target femtocell is greater than or equal to the required SINR of the target femtocell that will be based on the macrocell load.

$$AHM\_CL = max\left\{0, HM_{max}\left(1-\left(\frac{RSRP_m}{RSRP_{fj}}\right)^2\right)\right\}$$

$$subject\_to\begin{cases}\gamma^{m}_{mue}(t) \geq \theta \\ \gamma^{fj}_{mue}(t) \geq \gamma^{rfj}_{mue}(t)\end{cases} \tag{11}$$

b. For the inter-femtocell HO category, the AHM-CL is also calculated through three cascade stages. First, we make the computation of the adaptive HM (AHM) based on the RSRPs of both the serving femtocell and the target femtocell under the condition that: a) the SINR of the user with regard to the serving femtocell is good (i.e., greater than a predefined threshold) to avoid the RLF and b) the SINR of the user with regard to the target femtocell is greater than or equal to the SINR of the serving femtocell to force the FUE to offload from the congested femtocell.

$$AHM = max\left\{0, HM_{max}\left(1-\left(\frac{RSRP_{fi}}{RSRP_{fj}}\right)^2\right)\right\}$$

$$subject\_to\begin{cases}\gamma^{fi}_{fue_i}(t) \geq \theta \\ \gamma^{fj}_{fue_i}(t) > \gamma^{fi}_{fue_i}(t)\end{cases} \tag{12}$$

Second, compute the required SINR of the target femtocell that will be based on the congested femtocell load, which according to [9] can be written as:

$$\gamma^{rfj}_{fue_i}(t) \geq \gamma^{fj}_{fue_i}(t) - (L_{fi}.AHM) \tag{13}$$

From (13) reducing the SINR of the target femtocell will lead to an early HO decision that will give the opportunity to make a balance load between the two femtocells with a higher throughput.

Finally, the AHM-CL is computed based on the RSRPs for both the serving femtocell and the target femtocell under the condition that: a) the SINR of the user with regard to the serving femtocell is good (i.e., greater than a predefined threshold), b) the SINR of the user with regard to the target femtocell is greater than or equal to the required SINR of the target femtocell that will be based on the serving femtocell load.

$$AHM\_CL = max\left\{0, HM_{max}\left(1-\left(\frac{RSRP_{fi}}{RSRP_{fj}}\right)^2\right)\right\}$$

$$subject\_to\begin{cases} \gamma^{fi}_{fue_i}(t) \geq \theta \\ \gamma^{fj}_{fue_i}(t) > \gamma^{rfj}_{fue_i}(t) \end{cases} \tag{14}$$

c. For inbound and inter-femtocell HO categories, the ATTT-CL will be based on the corresponding AHM-CL and the UE velocity to avoid the ping-pong handover (PPHO) problem and can be determined as in [18]:

$$ATTT\_CL = 0.001\left(\frac{1}{V_{mue,fue_i} \times AHM\_CL}\right)^{-0.974} \tag{15}$$

Hence, choosing the target cell based on the proposed AHCPs-CL can be written as:

$$RSRP_{fj}(t) > RSRP_{m,fi}(t) + AHM - AHM\_CL; forATTT\_CLtimeduration \tag{16}$$

Algorithm 1. AHCPs-CL

```
start
initialize the network parameters [BS location, BS power, path losses, noise, UE location, velocity, ... etc.]
input θ, W, Tth
  for each mue, fue_i > 0 do
        if mue or fue_i moves to femtocell fj coverage area then
      calculate ToS^{fj}_{mue,fue_i} , L_fj, γ^{fj}_{mue,fue_i}
      if ToS^{fj}_{mue,fue_i} > T_th , L_fj > 1, γ^{fj}_{mue,fue_i} > θ
        save fj in the NCL N*_fj
    end if
      if the conditions of (9) or (12) are satisfied then
          compute the corresponding AHM according to (9) or (12)
          compute γ^{rfj}_{mue}(t), γ^{rfj}_{fue_i}(t) according to (10) or (13) respectively
      end if
      if the conditions of (11) or (14) are satisfied then
          compute the corresponding AHM-CL according to (11) or (14)
          compute the corresponding ATTT-CL according to (15)
      end if
    if the inequality in (16) is satisfied by the corresponding AHM, AHM-CL, ATTT-CL then
    Handover the mue or fue_i to fj
      else
    the current serving cell remains the same
      end if
      end if
  end for
```

3. RESULTS AND DISCUSSION

3.1. Inbound handover category

We test the effectiveness of the proposed AHCPs-CL on HO performance in a B5G/6G network. The simulation network parameters are adjusted based on 3GPP Release 17 and illustrated as in Table 2. Two frequency plans will be implemented. In plan 1, macrocell and femtocell use the same carrier frequency, Ғ (i.e., Ғ=3.5 GHz). In plan 2, macrocell and femtocell use different carrier frequencies (i.e., macro_ Ғ=3.5 GHz, femto_ Ғ=28 GHz).

Table 2. Simulation parameters

Parameters	Values
Transmitted power of femtocell	20 dBm [19]
Transmitted power of macrocell	46 dBm [19]
Bandwidth	20 MHz [23]
Macrocell carrier frequency	3.5 GHz [23]
Femtocell carrier frequency	3.5 GHz [23], 28 GHz [10]
Number of femtocells	5 [18]
σ^2	-104 dBm [19]
N_{mue}^{m}	Variable from 50–100 [19]
$N_{fue_i}^{fi}$,$N_{fue_j}^{fj}$	Variable from 3–7 [19]
$R_{fue_i}^{fi}$	1 (Normalized value) [19]
R_{mue}^{m}	0.25 (Normalized value) [19]
Macrocell radius	500 m [24]
Femtocell radius	50 m [24]
Path loss of macrocell	Release 17, 3 GPP UMa model [25]
Path loss of femtocell	Release 17, 3 GPP InF model [25]
User velocity	1Km/h-12km/h [26]
θ	-35 dB [18]
T_{th}	5 s [27]

So first, we compare our proposed model HO performance with respect to the AHCPs in [18] using frequency plan 1 when L_m=1 (i.e., the serving cell is fully loaded). From Figure 4, we can observe that during UE movement, the SINR of the congested serving macrocell will decrease and go to the outage, while the SINR of the target femtocell will increase. So, it is better to make an early switch to the ongoing service cell to decrease the possibility of service shortages. Therefore, we can find that the presented model (AHM-CL) outperforms the other AHM model by enhancing the transition between the congested serving cell and the target cell prior to the crossing point between the SINR of the source and destination (i.e., the SINR of the congested macrocell and target femtocell). So, this will enhance the overall SINR and will try to sustain the UE connectivity by having good SINR for each UE as much as possible. While the connection of the previous AHM model will not switch from the serving cell to the target cell until it reaches the equivalent AHM level, Hint: the initialization of the HO is followed by the HO decision when TTT takes place.

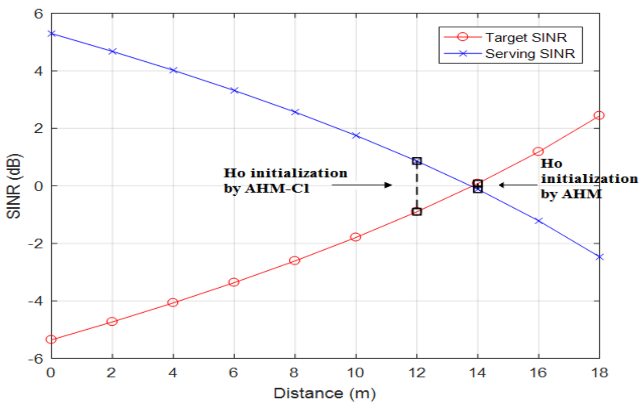

Figure 4. Comparison of AHM-CL vs AHM for different SINR in inbound HO, L_m=1, using freq. plan 1

Throughput Performance actually depends on the received SINR level [28]. Hence, we can notice in Figure 5 that although the two network tiers (i.e., macrocell and femtocell) have the same bandwidth, our proposal, AHCP-CL, outperforms the AHCP by maximizing the UE mean throughput. That's because our proposal will make early HO based on the serving cell load, while the AHCP will remain constant because it does not depend on the cell load factor. Therefore, the UE mean throughput will be improved. Example: When the serving cell load is fully (L_m=1), the UE mean throughput increases from 270 Kbps to 281 Kbps. Also, we can notice that in our proposed model, the change in the UE mean throughput against the load factor is not large because the level of the induced AHM-CL using the same frequency plan is small; thus, the early shifting based on the AHM-CL will also be small.

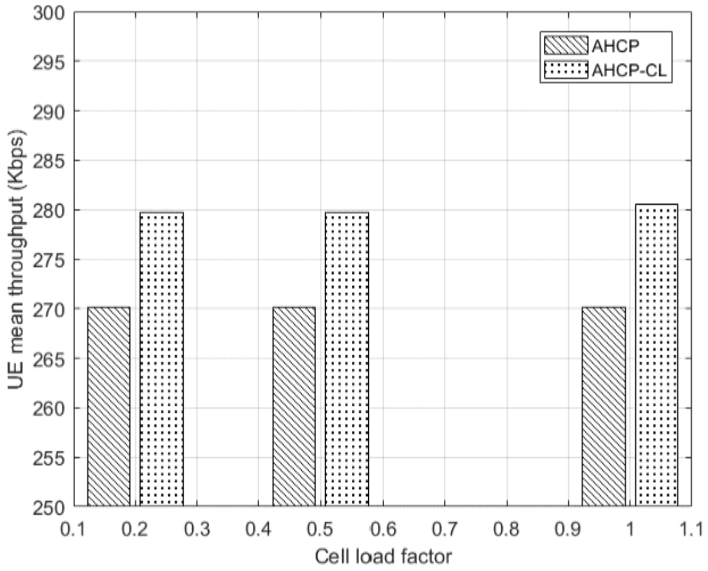

Figure 5. UE mean throughput vs cell load factor, using freq. plan 1

In Figure 6, we compare our proposed model HO performance with respect to the AHCPs that were described in [18] using frequency plan 2 (i.e., macrocell and femtocell are operating at different frequencies) when L_m=1. We can find that the level of the AHM and AHM-CL increased compared to that in plan 1 (i.e., macrocell and femtocell are operating at the same frequencies) because the interference on the macro-tier decreased, which led to an increase in the SINR level, which the HM level depends on. From Figure 6, we can notice that by using the AHM-CL proposed model, the SINR of femtocell and macrocell will reach 28.5 dB and 36 dB, respectively, while in the AHM model, the SINR of femtocell and macrocell will reach 36 dB and 35 dB, respectively. Thus, we can conclude that the corresponding RSRP of femtocell in the AHM model will be higher than the corresponding RSRP of femtocell in the AHM-CL model, which will increase the AHM level value over that of the AHM-CL level value (i.e., in (9) and (11) are implemented).

Actually, as the HM level increased, the TTT value increased [18]. Figure 7 illustrates the AHCPs-CL values (i.e., AHM-CL and ATTT-CL) and the AHCPs values (i.e., AHM and ATTT) using different UE velocity forL_m=1. From Figure 7, we can see that the level of ATTT increased by increasing the UE velocity while the ATTT-CL remained low, that's because of the low result level of AHM-CL (AHM-CL=2 dB) and the high result level of AHM (AHM=7 dB). Therefore, the congested macrocell will perform faster HO decisions using our proposed model than that of the other model.

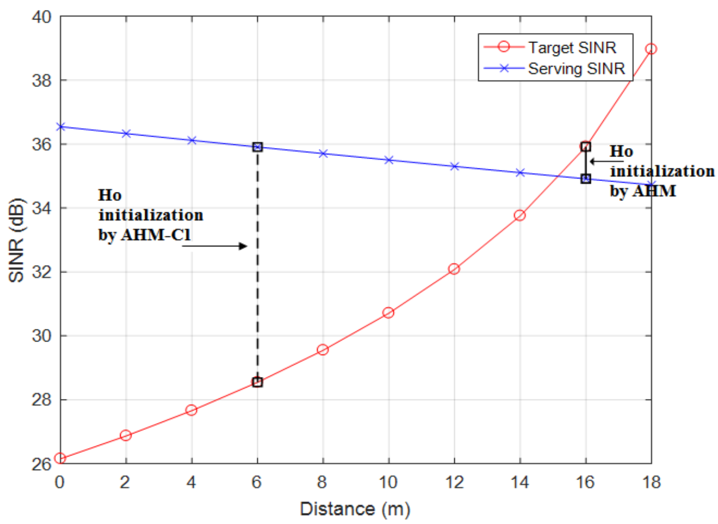

Figure 6. Comparison of AHM-CL vs AHM for different SINR in inbound HO, L_m=1, using freq. plan 2

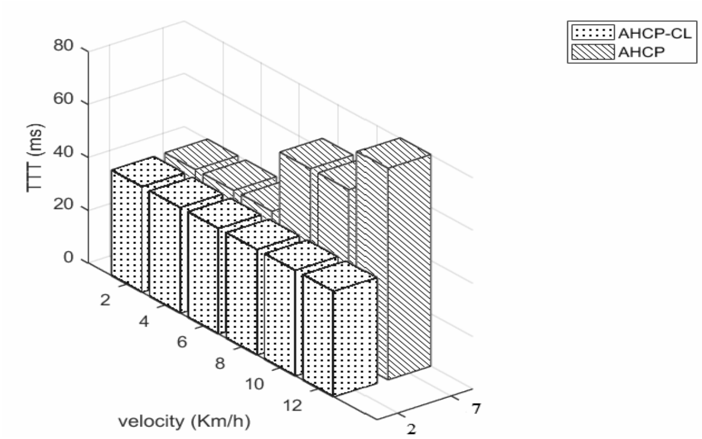

Figure 7. AHCP-CL vs AHCP against velocity, L_m=1, using freq. plan 2

Figure 8 shows the effect of load factor on bandwidth availability when the serving users are 7 FUE and 100 MUE. Figure 9 shows a superior enhancement in the UE mean throughput by using our proposed model compared to that of the other model. Since, when serving cell load is low (i.e., L_m=0.2), the UE mean throughput increases from 6 Mbps to 9 Mbps; when serving cell load is moderate (i.e., L_m =0.5), the UE mean throughput increases from 6 Mbps to 12 Mbps; and for full serving cell load (i.e., L_m=1), the UE mean throughput increases from 6 Mbps to 20 Mbps. This increase is due to the early handoff to the femtotier based on the serving cell load.

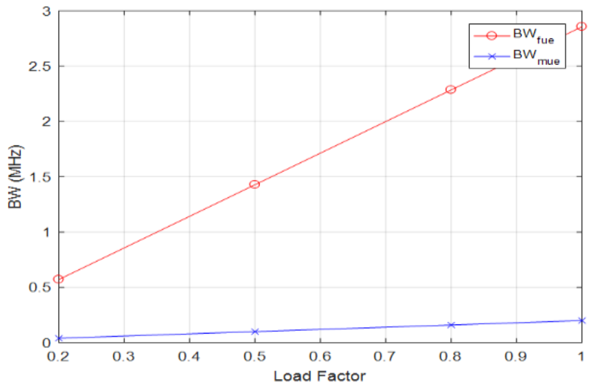

Figure 8. Required BW vs cell load factor, using freq. plan 2

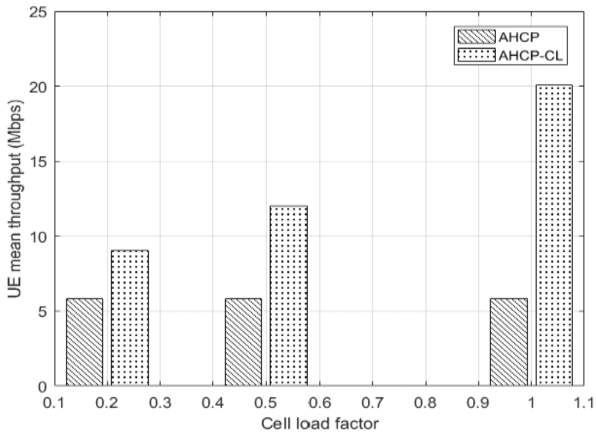

Figure 9. UE mean throughput vs cell load factor, using freq. plan 2

3.2. Inter-Small HO category

PPHO is the major problem that occurred in Inter-Small HO and should be considered. Alhabo and Zhang [9] was also performing the HO decision based on the serving cell load using setting HM and TTT values where a large number of overlapped small cells were deployed in the macrocell (100 small cells). We used the same simulation network parameters as in [9] to evaluate our proposed model.

So, to perform the HO decision in the Inter-Small cell case, the AHM-CL is computed using the three cascade stages that are discussed above. The setting HM based on [9] is set to be 4 dB if user velocity Vue ≤ 20 Km/h, 3 dB if 20 Km/h < Vue ≤ 50 Km/h, and 2 dB if Vue > 50 Km/h. Possible PPHO can be determined when the *ToS* for a UE in a cell is smaller than the predefined [9]. So that we can compare our proposed model's performance to that of the other model that was presented in [9]. Figure 10 illustrates that by increasing the UE velocity, it can divide the performance into two separate regions. Region 1: for low velocity (Vue < 50 Km/h). Region 2: for moderated to high velocity (Vue ≥ 50 Km/h), in both of the presented models, UEs will be served via the macrocell after going into region 2, owing to the *ToS* threshold condition (i.e., (8)) that is presented in both models. While in region 1, the presented model will outperform the other model [9] by decreasing the amount of PPHO possible effects. As illustrated in Figure 10, our system will not exceed one PPHO due to the enclosure of the loading effect, the AHM-CL level, and the *ToS* condition. Absolutely, as the number of PPHO decreases, the overall network throughput will increase and resource utilization will be more efficient.

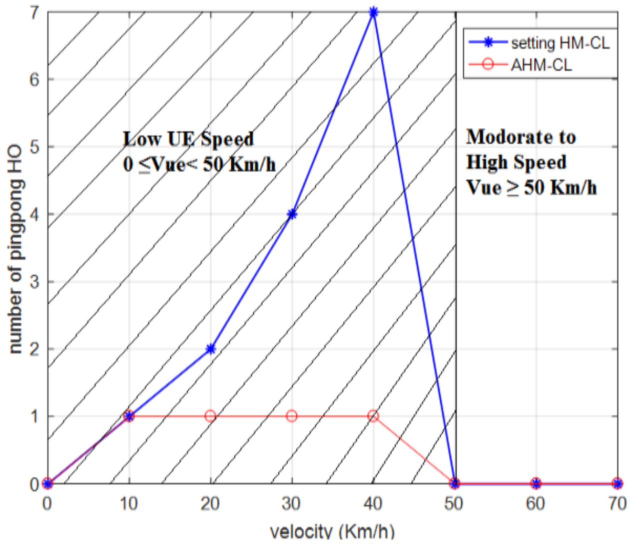

Figure 10. Number of PPHO against UE velocity, L_{fi}=1

4. CONCLUSION

In this paper, we propose adaptive handover control parameters based on serving cell load and other different environmental constraints in a B5G/6G heterogeneous two-tier network. An early HO decision based on the congested cell load is made to balance the network cells load. To evaluate our proposed model, two frequency plans are implemented in the Inbound HO category. We found that in both frequency plans, our proposed AHCPs-CL model outperforms the other AHCPs model by maximizing the UE mean throughput. As in plan 1, the UE mean throughput increased from 270 Kbps to 281 Kbps when the serving cell was fully loaded, while in plan 2, the UE mean throughput increased from 6 Mbps to 20 Mbps when the serving cell was fully loaded. In addition, we evaluate the PPHO effects on Inter-Small HO. We found that our proposed model outperforms the setting HM-CL model by decreasing the amount of PPHO between the overlapped small cells.

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