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Enhancing the Handover Performance in the Mobile Heterogeneous Network Based on the Expected Zone of Handover Events

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Abstract : This paper aims to enhance the handover performance in the heterogeneous networks (HetNet)by reducing the need to make handover under the specified conditions and also reducing the handover failure, thisstudy divided the target cell for ten assumed circular zones, where zones start with radius Rh=R/10 from center of target cell, then the next zone is increased by R/10, then the simulation is carried out for each assumed zone using selective values of TTT (160,480 and 640 ms) in order to determine the best circular zone of more handover events (zone of handover) in the coverage area for the target cell and other zone for no handover events (zone of no handover).

The paper found that the most practically suitable zone for more handover events was the zone which its radius represents 86.6% of the radius of the coverage area for the target cell. Whereas, the remained zone (the zone between the zone of handover and the edge of target cell is considered a zone for no handover events. Also, the angle of chord (Θ) for the expected zone of handover events from the horizontal axis is 60˚, i.e. if the UE moves by certain velocity and with a moving angle less than or equal to 60˚, then it will have a large probability to make handover events after satisfying the other handover conditions. Otherwise, its probability to make handover events is very low.

The paper extracted that after determining more suitable handover zone and implementing the different fixed and chosen values of TTT, then a remarkable enhancement occurred in the handover performance and it was obvious at high speed of travelling for the user.

Keywords: *cell, handover, HetNets, performance, zone.*

1. INTRODUCTION

Heterogeneous Network (HetNet) is a cellular network enriched with a number of smaller and simpler Base Stations (BSs), with a widely varying transmit powers, coverage areas, carrier frequencies, backhaul connection types and communication protocols [1][2].

The high density areas within the network, like campuses, malls, and stadiums where people gather and use their voice and data devices to interact and entertain, need to provide additional capacity. The HetNet enables an operator to cope with the lack of coverage and capacity as possible, by deploying lower power small cells or low power node (LPN) in the macrocells coverage areas as in Figure (1) [3][4][5].

When UE moves to a new base station, call will be reconnected to new base station. This process is called the handover, the main aim of the handover is the maintenance of quality of service and preservation of cellular system capacity [6][7][8].

Enhancing the performance of a handover for mobile users within a HetNet scenario mainly depends on the setting of the handover parameters such as the user position from the center (from BS location of the target cell), the dedicated time to triggering handover TTT, as well as the speed of user during the handover process, especially in regions with high traffic demand inside the Macrocells.

In order to avoid large number of handover failure and ping pong effect time to trigger (TTT) is used [9][10][11][12]. In [1], the relevant statistics obtained from the 3GPP (compliant

HetNet Simulator) was extracted, and subsequently, these statistics are integrated into their analytical model to analyze handover failure probability under fluctuating channel Conditions. The results showed that fading can significantly degrade the handover performance in HetNets with vehicular users.

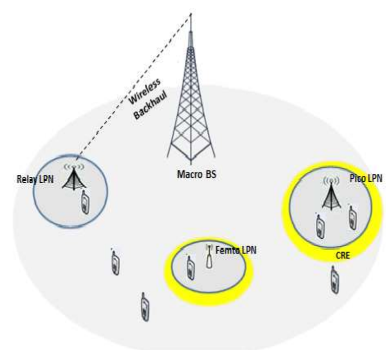

Fig .1. Heterogeneous Network

A simple geometric abstraction to derive analytic and semi-analytic expressions is developed for macrocell UE (MUE) and picocell (PUE) HF probabilities for scenarios with no fading and with fading respectively.

In [3], the authors computed the user average capacity exploiting a novel analytical framework based on a Markov chain that considers the evolution of the UE state during the handover process. They showed that the proposed policy outperforms a standard Time to Trigger (TTT) fixed policy. A general theoretical analysis was derived to characterize the user performance as a function of the mobility model, the power profile received from the neigh boring cells and the handover parameters. This strategy outperforms conventional handover optimization techniques by exploiting the context information.

In [13], the hysteresis margin and load balancing problem in a 3GPP LTE heterogeneous network have been investigated. Firstly, the A3 event, Hysteresis Margin (HM) and Cell Individual Offset (CIO) objectives are not considered fixed for every cell. Then the complexity of the problem was analyzed and a practical algorithm is proposed to calculate.

Adaptive hysteresis margin and load balancing in heterogeneous network. The results show better performances, such as redundant handover reduction and improvement of the network performance.

In [14], the researchers provided theoretical analysis of handover failures in HetNets with L3 filtering. It is shown that for high speed users, shorter L3 sampling periods should be used to improve the handover failure performance of both MUEs and PUEs. For an MUE travelling at 61 km/h, an improvement of 8.74 % is observed in handover failure performance, when sampling period is reduced from 200 ms to 50 ms. The negative effect of reducing the L3 sampling period is that it will increase the UE power consumption.

In [15], the relation between handover failure and ping-pong rates was characterized in a 3GPP heterogeneous network scenario as a function of relevant system parameters, such as time-to-trigger, user equipment velocity, range expansion bias, etc.Under the assumptions (the picocell coverage and radio link failure areas are circular regions, and that users follow linear trajectories), handover failure and ping-pong rates are derived in closed-form expressions.

This paper attempts to determine the expected areas (or zones) that include most of handover events, and expected a zone that with no handover events in the target cell for handover in the HetNet.This study also aims to make a balance between minimizing the rate of HF and HPP as possible.

2. Proposed Approach

In the following the implement steps of proposed approach:

1- The area of coverage for the target cell is divided into 10 zones or handover (H) concentric circles (Z1, Z2, Z3,…, Z10) with radius (R_h) starts from R/10 and it is increased by R/10 where R represents the radius of target cell for the handover and the R_h is calculated from the center of target cell as in Figures (2) and (3).

2- The simulation carried out based on assumed zones and selective fixed values of TTT to determine the suitable zone (circle) for handover events or the zone that it includes approximately most of all events of handover for all handover requests and the other zone where no handover events exist or where there is very low probability to occur handover.

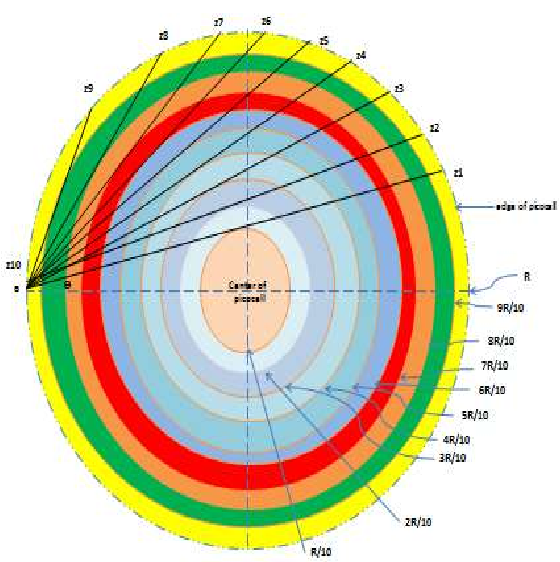

Fig .2. The ten zones, their tangents and angles.

As shown in Figure (2), there are 10 zones or H concentric circles as shown in Table (1).

Table 1. Radiuses of assumed H circles

Radius of H zone	Value (R)	Value [m]
R_{h1}	R/ 10	6.4
R_{h2}	2R/ 10	12.8
R_{h3}	3R/ 10	19.2
R_{h4}	4R/ 10	25.6
R_{h5}	5R/ 10	32
R_{h6}	6R/ 10	38.4
R_{h7}	7R/ 10	44.8
R_{h8}	8R/ 10	51.2
R_{h9}	9R/ 10	57.6
R_{h10}	R	64

Each zone was studied separately, then the chord line and its angle from the horizontal axis for each handover zone was calculated. For instance, handover zone Z7 shown in the Figure (3), the chord length (L) for Z7 is line ae and its angle is Θ.

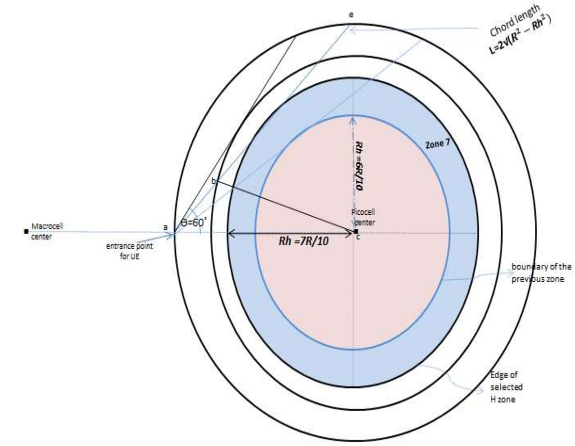

Fig .3. Example for handover zone 7.

3. Simulation

The simulation was carried out for ten hours (assumed as busy hours per day in the network from 8:00 am to 6:00 pm) and repeated for one month in a chosen highly populated area in the urban area to obtain the performance of handover by calculating the probabilities of HF, handover success (HS) and HPP through the fixed selective values of TTT.

The simulation was repeated for the specified UE's speed (VUE= 120 km/h, 60 Km/h, 30 Km/hand 3 Km/h), then the results collected and tabulated in the Tables, after that the comparison between the results of fixed selective values of TTT was made.

The proposed network was implemented according to one cluster of circular cells with three cells f HetNet, i.e. 3 macrocells and 3 picocells (one picocell per macrocell) as in Figure (4) and each HetNet cell was studied separately). The results were verified based on handover from microcell into picocell and vice versa, and this paper doesn't study the handover between macrocells themselves.

Also, in the proposed approach there are picocells located near the border of their macrocells and others picocells inside their macrocells but their locations far from the border of their macrocells as shown in Figures (4) and (5), each picocell was supported by cell range extension (CRE) technique to provide higher capacity and better coverage for the mobile users in regions with high traffic demand.

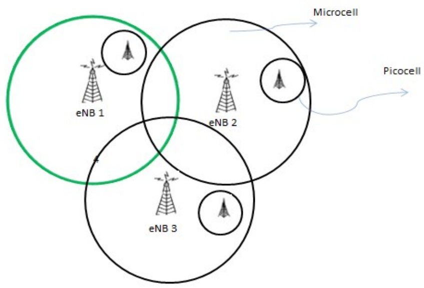

Fig .4. HetNet Network Model

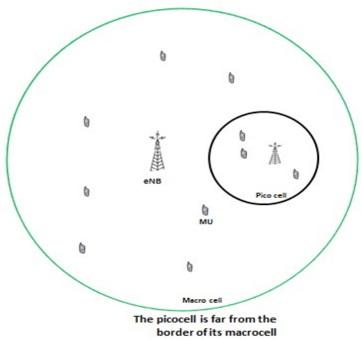

Fig .5. one microcell with one picocell

4. The probability Models:

When the call for the UE is ongoing and it requests a handover from the serving cell to the target cell, then one case from three cases or actions will occur: either the request of handover succeeds, fails to handling call for the target cell, or there is no need to make handover.

$$P_{HA} = (P_{HS} + P_{HF} + P_{nonH}) = 1 \quad (1)$$

whereP_{HA} is the probability of occurring action for the handover request,P_{HS} is the probability of handover success,P_{HF} is the probability of handover failure, andP_{nonH} is the probability of no need for the handover to occur for that request of handover and n is the number of request handover, the explanation for the mentioned cases are as follows:

4.1 The probability of handover failure (HF)

There are two situations that lead to the failure of handover to the target cell as follows:

1- When the remaining time to finish a call (T_R) is less than the timededicated for the triggering handover TTT, i.e. (T_R< TTT).

This case will be referred to as case one for handover failure (HF1) and this case achieves for both the MUEs and PUEs.

$$P_{HF1} = P_{HF1_{MUE}} + P_{HF1_{PUE}}$$
$$= \frac{N_{HF1_{MUE}}}{N_{H_{MUE}}} + \frac{N_{HF1_{PUE}}}{N_{H_{PUE}}} \quad (2)$$

Where $P_{HF1_{MUE}}$ is probability of handover failure for the MUEs in case one,$P_{HF1_{PUE}}$ is probability of handover failure for the PUE in case one,$N_{HF1_{MUE}}$number of handover failure for MUEs,$N_{HF1_{PUE}}$number of handover failure for PUEs, $N_{H_{MUE}}$is the total number of request handover for MUEs and $N_{H_{PUE}}$ is the total number of request handover for PUEs.

2- When the received signal strength (RSS) for the serving cell is very weak due to RF impairments and this makes it less than RSS for the target cell plus threshold through the period of TTT, where the following condition should be satisfied.

i.e. RSS_S<= RSS_T + threshold (3)

This case will be referred case two for handover failure (HF2).

$$P_{HF2} = P_{HF2_{MUE}} + P_{HF2_{PUE}}$$
$$= \frac{N_{HF2_{MUE}}}{N_{H_{MUE}}} + \frac{N_{HF2_{PUE}}}{N_{H_{PUE}}} \quad (4)$$

Where $P_{HF2_{MUE}}$ is the probability of handover failure for the MUEs in case two,$P_{HF2_{PUE}}$ is the probability of handover failure for the PUE in case two,$N_{HF2_{MUE}}$number of handover failure for MUEs,$N_{HF2_{PUE}}$number of handover failure for PUEs.

Therefore, the total probability of HF becomes:

$$P_{HF} = P_{HF} + P_{HF} \quad (5)$$

4.2 The probability of handover success (HS)

There is one case that leads to handover success. This case happens if the following two conditions are satisfied:

When the remaining time to finish call is larger than the dedicated time for the triggering handover (TTT), i.e.:

T_R> TTT (6)

2- The RSS for the serving cell (RSS_S) is less than RSS for the target cell (RSS_T), and this situation remains throughout the period of TTT until the period of TTT has finished, i.e.:

RSS_S<RSS_T (7)

Therefore, the total probabilities of HS for MUE the and HS for PUE becomes:

$$P_{HS} = P_{HS_{MUE}} + P_{HS_{PUE}}$$
$$= \frac{N_{HS_{MUE}}}{N_{H_{MUE}}} + \frac{N_{HS_{PUE}}}{N_{H_{PUE}}} \quad (8)$$

Where $P_{HS_{MUE}}$ is the probability of handover success for the MUEs,$P_{HS_{PUE}}$ is the probability of handover success for the PUE,$N_{HS_{MUE}}$ number of handover success for MUEs,$N_{HS_{PUE}}$number of handover successes for PUEs.

4.3 The probability of not complete the handover (Hnc) for the handover attempt

There are four situations that lead to keeping the connection with the serving cell and stopping the procedures to decide and execute the handover to the target cell for the handover attempt and they are:

1. When initiate the handover procedure but T_R less than TTT period then the HS and HF conditions not satisfied.
2. It initiates the handover procedure and before finishing TTT period but the RSS from the serving cell return large than RSS from target cell, then the HS and HF conditions not satisfied.
3. After UE succeeded to handle from cell A to cell B and it needs to initiate a new handover for the same ongoing call but the TS for UE in cell B was less than MTS, then the HS and HF conditions not satisfied.
4. After UE succeeded to handle from cell A to cell B and it needs to initiate a new handover for the same ongoing call but T_R less than MTS, then UE will continue served by cell B until it completes T_R for its call.

This case will apply for the MUEs and PUEs, therefore:

$$P_{Hnc} = P_{Hnc\,MUE} + P_{Hnc\,PUE}$$

$$= \frac{\text{number of } Hnc_{MUE} + \text{number of } Hnc_{PUE}}{\text{Total number of handover attempts}} \quad (9)$$

Thus, from equations (5), (8) and (9) the equation (1) under the conditions becomes as follows:

$$P_{H\_init} = \left(P_{HS_{co}} + P_{HF_{co}} + P_{Hnc}\right) = 1 \quad (10)$$

Where HS_{co} and HF_{co} handover success and handover failure under conditions respectively.

This makes HS under the conditions as following,

$$P_{HS_{co}} = (1 - (P_{HF_{co}} + P_{Hnc})) \quad (11)$$

4.5 The probability of ping pong handover Model

When the UE moves to the target cell and it succeeds to make handover and it needs to return back to the previous serving cell through the same ongoing call, then the ping pong handover happens and this action may happen more than one for the same ongoing call.

That means, the ping pong of handover occurs when the RSS for the serving cell is less than RSS for the target cell (RSS_S<RSS_T), and after the handover succeeds to the target cell but the RSS for the previous serving cell becomes larger than the last serving handover (RSS_S<RSS_T), where the dedicated time to stay (TS) in the last serving cell is larger than the minimum time of stay in the cell (MTS), i.e. TS < MTS.

$$P_{PP} = P_{HPP_{MUE}} + P_{HPP_{PUE}}$$

$$= \frac{N_{HPP_{MUE}}}{N_{H_{MUE}}} + \frac{N_{HPP_{PUE}}}{N_{H_{PUE}}} \quad (12)$$

Where $P_{HPP_{MUE}}$ is the probability of ping pong handover for the MUEs, $P_{HPP_{PUE}}$ is the probability of ping pong handover for the PUE, $N_{HPP_{MUE}}$ number of ping pong handover for MUEs, $N_{HPP_{PUE}}$ number of ping pong handover for PUEs.

5. Simulation Parameters

To implement the simulation, there are important parameters which should be known and have real values, Table (2) shows these parameters and their values.

Table 2. Simulation parameters

Parameters	Macro Cell	Pico cell
Radius (R) [m]	500	64
VUE [Km/h]	120,60,30 and 3	120,60,30 and 3
Carrier Frequency [Ghz]	2	2
Bandwidth[Mhz]	10	10
BS transmission Power [dBm]	46	30
Cell Range Extension (CRE) [dB]	12	
TTT (first stage [ms])	160,480 and 640	160,480 and 640
TTT (second stage [ms])	160,480 and 640	160,480 and 640
MTS [ms]	1000	1000
Standard deviation of shadowing (sigma) [dB]	6	10
Number of subcarriers	100	
Subcarrier spacing [kHz]	15	
Resource Block Bandwidth [kHz]	180	
Max. number of calls [call]	150	
Time interval of call [s]	120	
Cell loading	100%	
Handover zone radius (R_h)	R/10, 2R/10, …, R.	R/10, 2R/10,…, R.

6. The Results and Discussion

The main information used in the first stage of simulation for the handover performance such as the chord line and range of angles are presented in the Table (3).

Table (3): The main parameters for assumed ten handover zones

Zone	**ZoneRadius (R_h) [m]**	**Chord line $L = 2\sqrt{R^2 - R_H^2}$ [m]**	**Range of angles (Θ) [°]**
1	6.4	127.3	0-5.7
2	12.8	125.4	0-11.5
3	19.2	122.1	0-17.5
4	25.6	117.3	0-23.6
5	32	110.85	0-30
6	38.4	102.4	0-36.9
7	44.8	91.4	0-44.4
8	51.2	76.8	0-53.1
9	57.6	55.8	0-64.1
10	64	0	0-90

In the Table (3) the chord line (L) and range of angles for Θ (from horizontal axis to the chord line) for each zone are calculated.

The first simulation was implemented to determine the suitable zone for handover events and the other zone where there are no handover events as shown in Figure (6), therefore the simulation was carried out for each assumed zone separately.

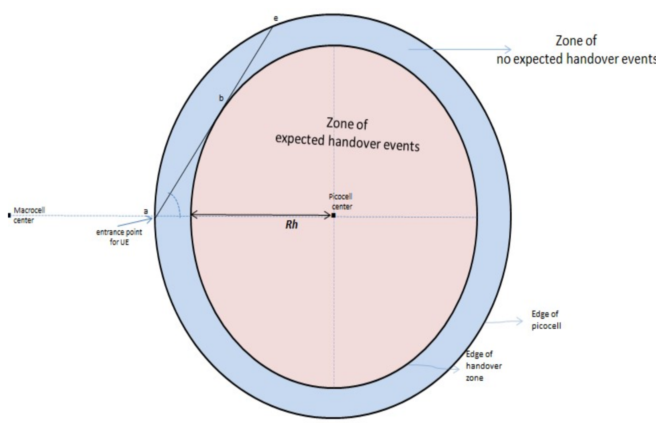

Fig .6. Regions of the prob. of handover and no prob. of handover

The Results for the first stage of simulation:

The results of simulation were collected and tabulated using selective values of TTT (160,480 and 640ms), these values are more practical. The best results for the handover performance were in zone 9 and zone 10 as shown in the Tables (4) and (5).

Table 4. Handover performance for handover zone nine

The total prob. with velocities		**VUE = 3 Km/h**	**VUE = 30Km/h**	**VUE = 60 Km/h**	**VUE= 120 Km/h**
TTT=160ms	PHF	0.120	0.126	0.130	0.135
	PHnc	0.200	0.194	0.199	0.225
	PHPP	0.120	0.128	0.136	0.146
TTT=480ms	PHF	0.136	0.139	0.144	0.148
	PHnc	0.210	0.200	0.215	0.211
	PHPP	0.093	0.097	0.101	0.107
TTT=640ms	PHF	0.144	0.148	0.154	0.158
	PHnc	0.200	0.199	0.210	0.210
	PHPP	0.077	0.086	0.096	0.106

Table 5. Handover performance for handover zone ten

The total prob. with velocities		V_{UE} = 3 Km/h	V_{UE} = 30 Km/h	V_{UE} = 60 Km/h	V_{UE} = 120 Km/h
TTT= 160ms	PHF	0.105	0.111	0.116	0.120
	PHnc	0.222	0.199	0.201	0.215
	PHPP	0.141	0.153	0.168	0.177
TTT= 480ms	PHF	0.120	0.125	0.129	0.131
	PHnc	0.212	0.210	0.200	0.220
	PHPP	0.110	0.120	0.129	0.140
TTT= 640ms	PHF	0.122	0.129	0.132	0.135
	PHnc	0.189	0.192	0.215	0.210
	PHPP	0.090	0.098	0.109	0.124

The comparison between the two handover zones 9 and 10

The Figures (7),(8) and (9) provide comparisons between handover zones 9 and 10 for the handover performance at TTT=160,480 and 640ms.

At TTT=160ms

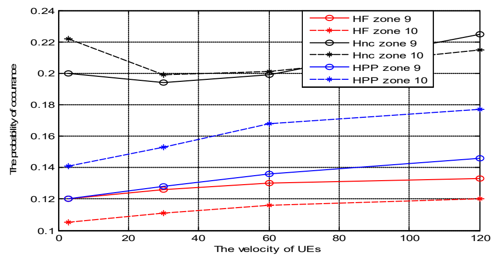

Fig .7. Comparison between zones 9 and 10 at TTT=160ms

At TTT=480ms

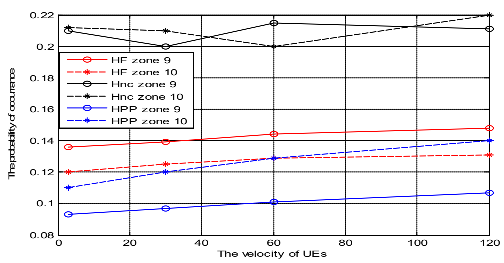

Fig .8. Comparison between zones 9 and 10 at TTT=480ms

At TTT=640ms

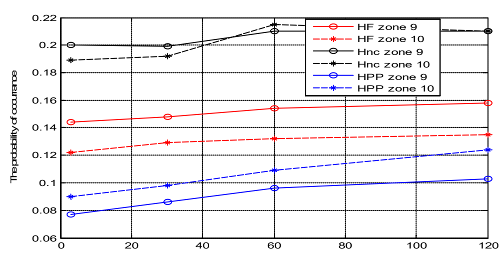

Fig .9. Comparison between zones 9 and 10 at TTT=640ms

The comparison between handover zones 9 and 10 as in Figures (7), (8) and (9) showed that zone 9 is the best handover zone of all other zone where the rates of HF and HPP were widely balanced and approaching.

Overall, the results clearly indicate that zone 9 is the best zone to get best results of handover performance, where the rate of HF reaches 13.5% and the rate of HPP reaches 14.7% at TTT= 160ms, while the rate of HF reaches 15.9% and the rate of HPP reaches 10.6% at TTT= 640ms.

The Results for the second stage of simulation

Further attempts should be made to optimizing and improve the handover performance by determining and specifying the best handover zone inside handover zone 9 to optimize the enhancement, the Table (6) shows the chord line and Range of angles ϴ for specific zone inside handover zone nine which its radius(□) is 55.43m and range of ϴ is [0-60].

Table 6. The main information for best assumed handover zone

suitable handover zone	R_h [m]	the chord line $L = 2\sqrt{R^2 - R_H{}^2}$ [m]	Range of angles (ϴ) [°] (from horizontal axis to the chord line)
Inside handover zone 9	55.43	64	0- 60

Table (7) shows the results of handover performance at using the selected values of TTT (160,480 and 640ms), Table (7) shows the results for best assumed handover zone (inside handover zone 9) which achieved best results for the handover performance.

Table **7.** The results of handover performance at TTT=160,480 and 640ms

The total prob. with velocities		V_{UE} = 3 Km/h	V_{UE} = 30 Km/h	V_{UE} = 60 Km/h	V_{UE}= 120 Km/h
TTT= 160ms	PHF	0.122	0.128	0.131	0.130
	PHnc	0.210	0.199	0.200	0.225
	PHPP	0.115	0.124	0.129	0.136
TTT=480ms	PHF	0.129	0.132	0.136	0.140
	PHnc	0.220	0.210	0.214	0.212
	PHPP	0.09	0.093	0.097	0.100
TTT=640ms	PHF	0.146	0.151	0.155	0.152
	PHnc	0.209	0.206	0.211	0.215
	PHPP	0.075	0.084	0.092	0.100

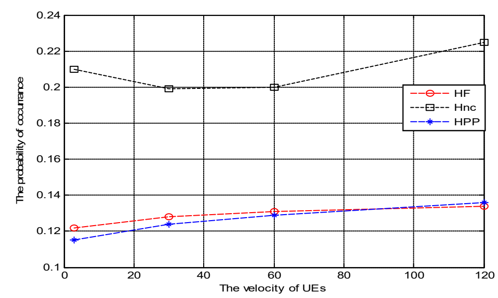

Fig .10. Results of handover performance at TTT=160ms

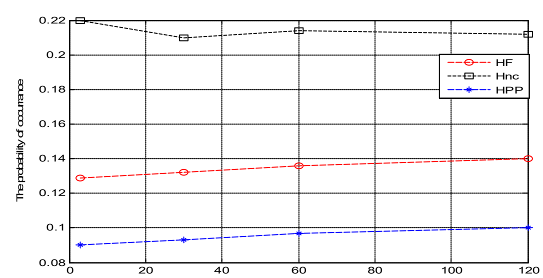

Fig .11. Results of handover performance TTT=480ms

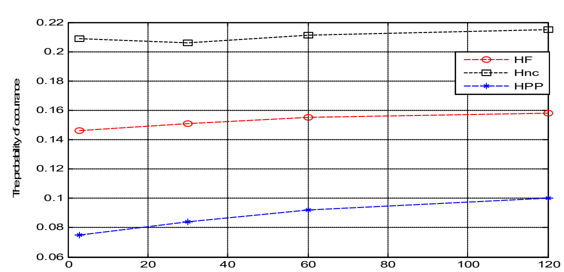

Fig .12. Results of handover performance at TTT=640ms

As shown in Table (7) and Figures (10),(11)and (12), the results of handover performance at TTT=160,480 and 640ms have shown significant enhancement and it was more clear at high speed of travelling for the UE, the results of handover performance were; at TTT= 160ms the rate of HF reaches 13.1% and the rate of HPP reaches 13.6%, while at TTT= 640ms the rate of HF reaches 15.2 % and the rate of HPP reaches 10%.

7. CONCLUSION

To enhance the handover performance in the mobile HetNets, initially this study divided the target cell for ten assumed circular zones, these zones start from radius Rh=R/10 (from center of target cell), then the next zone is increased by R/10.

It concluded that the best suitable zone of more handover events was the zone with a radius 86% of the radius of coverage area for the target cell and the remaining zone to edge of target cell as zone for no handover events and the angle of chord (Θ) for the expected zone of handover events from the horizontal axis is 60˚. This means if the UE move by certain velocity and its moving angle is less than or equals 60˚, then it has a large probability to make handover after satisfying other handover conditions, otherwise its probability to make handover is very low.

This study concluded that after determining suitable handover circle and implementing the different fixed values of TTT, then remarkable enhancement was achieved and it was more clear at high speed of traveling for the user, where the probability of HF reaches 13.1 % and the probability of HPP reaches 13.6% at TTT= 160ms, while the probability of HF reaches 15.2 % and the probability of HPP reaches 10% at TTT= 640ms.

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