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Call Admission Control Scheme and Handover Management in LTE Femtocell-Macrocell Integrated Networks

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Abstract

The femtocell technology is a quick and intelligent solution that improving system coverage and capacity to meet the great demand of services on broadband wireless access, the deployment of access point femtocells will unload a great quantity of traffic from the LTE macrocellular to be managed by the femtocellular network.

Switching seamlessly between macrocell and femtocell base stations is a major challenge of LTE femtocell-macrocell integrated system; which is performed by the handover procedure that can guarantee an efficient transfer of UE from/to or between femtocells, and also offer an effective management of handover calls in the system.

The intelligent LTE integrated system architecture, a generation and the optimization of neighboring list that contain the best cells for handover, efficient algorithm for call admission control, and also an optimized handover procedure are the most important topics for research.

The intelligent LTE integrated system architecture is necessary to satisfy different criteria, as minimizing handover interruption, guarantee and assure minimum signaling overhead due to frequent and unnecessary handovers…so to determine a single handover decision making policy is not sufficient to develop the performance, thus in this paper we propose a call admission control policy to reduce the redundant handovers in the system and an improved process to create a neighboring list with best cells for handover and an appropriate ones for successful and efficient handover.

Firstly, we present the LTE femtocell-macrocell integrated network architecture with a large deployment of femtocells. We propose the details signaling flux for handover procedure for different scenarios and the proposed CAC scheme to minimize the unnecessary handovers, based on an optimized neighboring list.

Keywords: LTE, CAC, handover, femtocell, macrocell, HeNB, eNodeB

1. Introduction

The actual wireless network require more data traffic with the exponential increased demand and number of users, but the capacities of macrocells still not sufficient to satisfy it.

The mobile networks are attempted to provide high demand of bandwidth with low cost for diverse data and multimedia services but assuming an enhanced quality of service QoS.

The network operators actually try to propose effective solutions to improve existing infrastructure, and to expect the huge demand of traffic by introducing more and smaller base stations to permit higher amount per area.

The femtocell is one of the best solutions proposed for network operator to face the great demand of the growing capacity of wireless networks.

The femtocell is a miniature cellular base station or access point intended for use in home and small professional locations that works on the licensed spectrum for cellular service providers, and designed to integrate seamlessly the different existing technologies as a complete indoor coverage solution, with low price, and low power, usually cover an area with the radius of 5 to 20 meters.

The different existing radio access technologies can contain the femtocells, it has been defined in Long Term Evolution LTE system by the name of Home eNodeB (HeNB), it acts as a small base station providing extended wireless LTE coverage inside the customer's home or small office, it can be easily installed just like a plug-and-play device.

The main performance advantage that femtocells can offer to LTE network is that they will increase the number of users obtain height data rates without any interruption or disturbances, Specially indoor where the Qos is less than outdoor, and the majority of mobile data is expended.

Switching a huge amount of traffic from the congested and the expensive LTE macrocell network is to be supported in femtocell network, that's the role of an intelligent deployment of access point femtocells in LTE femtocell-macrocell integrated network, which will also reduce the investment capital and improve the reliability of the mobile systems.

The implementation and the deployment of femtocells HeNBs in LTE system generate three scenarios for the handover procedures hand-in transfer (macrocell↔femtocell), hand-off transfer (femtocell↔ macrocell),and the inter-HeNB (femtocell↔femtocell).

Thousands of femtocells can be deployed in LTE network, which present a big number of candidate femtocells for handover, from eNodeB macrocell to HeNB femtocell or inter-HeNB handover.

The handover management of femtocell in LTE system is difficult and different from the current networks, so the efficient handling of handover procedure in LTE femtocell-macrocell integrated network is very essential for seamless movement of users which can reduce huge traffic loads in the network. The presence of great quantity of femtocells inside a LTE macrocell area and a large number of feasible targets femtocell candidates for macrocell to femtocell handover require a large neighboring list with many targets to select the optimal one for the handover.

The LTE network can receive a large amount of handover calls engendered by the HeNBs and the neighboring eNodeBs.

The call admission control scheme prioritize the handover calls in the macrocell eNodeB by including the concept of QoS adaptation provision this latter is applicable to accept handover calls in a macrocell network, the coverage of femtocell base station is small, so users move around it which creates some unnecessary handovers, which decrease the user's QoS level and it can be reduced by using an appropriate call admission control and resource management.

The call admission control strategy offers two levels thresholds of signal SNIR (signal to noise plus interference ratio) to decrease the unnecessary handovers, and due to available resources in the networks it does not distinguish between the newly arriving calls and with handover calls from femtocells.

In this paper, we present the complete signaling flux for the handover procedure in LTE femtocell-macrocell integrated network, and we suggest a CAC call admission control scheme respecting different criteria, signal level SNIR, the speed status of UE with QoS adaptation provision, an optimized neighboring list algorithm.

Generally users with high speed causes unnecessary handovers in the system, by moving through the femtocell, where an outbound handover occurs quickly after an inbound handover, and also impact and decrease the network performance.

The remainder of this paper is organized as follows. In part 2 we present the system architecture of LTE femtocell-macrocell integrated network, section 3 contain the design of optimized neighbor femtocell list in LTE integrated system, the proposed call admission control scheme is presented in section 4, and the last section is for the performance analysis for handover procedure via reducing some unnecessary handover in LTE integrated system.

2. Method and Technique

2.1 System Architecture of LTE Femtocell-Macrocell Integrated Network

The network architecture of LTE system consists of macrocells with eNodeBs base station on providing both user plane and control plane to the UEs, femtocells being a new addition to the existing components.

The HeNB is low-power access point involves the function of base station eNodeB, to gives the secure access to the network operator via internet.

The architecture of LTE network is presented in figure 1, the architecture includes the femtocell base station, the user equipment UE interfaces with a Home eNodeB (HeNB) over the air interface.

The HeNB Gateway HeNB-GW is an intermediate entity situated among HeNBs and the mobile core network, which performances as a concentrator and a virtual eNodeB base station to the MME and as MME to HeNB femtocells.

The HeNB-GW manages the traffic flux for large number of femtocells HeNBs, the flux comes also from different access networks and is then sent to the chosen destination networks.

The LTE femtocell-macrocell integrated system can support a large access point femtocell, thus a femtocell managing system is used to control and manage the HeNBs. The inter-eNodeB handover between the eNodeBs entities is realized by the X2 interface, but no X2 interface between neighboring HeNBs, there's no communication. However, every other connection between HeNB and the HeNB-GW or between this latter and the MME/S-GW is realized via S1 interface.

One of the most requirements for large femtocell deployments in LTE network is minimizing the level of operator participation while also reducing the impact of the dense deployment on the existing systems, Therefore the base station femtocell must integrate the network searching and scanning for available frequencies and also for other network resources. However, the networks with very large access point femtocells HeNBs need some more complicated management and self-organized network, the SON concept.

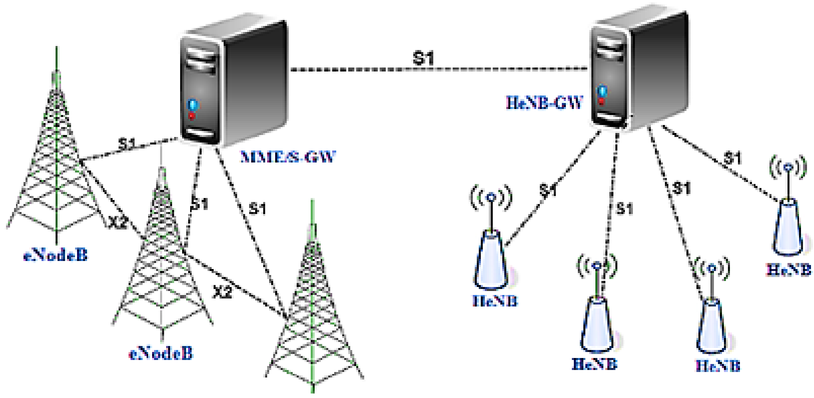

Figure1. Architecture of LTE femtocell-macrocell integrated system

2.1.1 eNodeB and HeNB femtocell Self-Organization Network

The deployment of a new technology is the important investment for any network operator. The SON concept gives the operator the possibility to decrease the human intervention in the installation and the configuration process by offering "plug and play" functionality in the base stations of the system.

The femtocells are required to be able to completely self-organize themselves so that there is no intervention from the user. Furthermore, as the quantity of HeNBs femtocells is expected to increase than macrocells, the manual maintenance and deployment of network is not flexible in a cost effective way for large implementation of femtocells.

The self-organization of networks is a new concepts that permits an important cost support of a variety for a good quality mobile communication services and applications, and it is a wide approach that involves several different functions used in special SON features, this latter contains three main functionalities are self-optimization, self-configuration, and self-healing each one define some essential procedure.

The self-configuration contains frequency allocation. The self-optimization consists of optimizing the neighboring list, power correction and adjustment with coverage optimization, in addition to optimizing the mobility robustness. In other hand, the self-healing contains the solution of most of the failures and procedures for automatic detection.

The good designed LTE femtocell-macrocell integrated architecture must support the efficient management of a large quantity of HeNBs, and also managing an important number of handover calls. In order to perform smooth and seamless handover the SON features enable the coordination concerning the HeNBs as well as between the HeNBs and the eNodeB. Whenever a mobile station needs to handover in a serving eNodeB macrocell area, it detects the presence of multiple neighboring HeNBs because of the large deployment of femtocells.

So for constructing an optimized neighboring list in the LTE integrated system, the neighboring HeNBs and the

HeNBs with the macrocellular eNodeB exchange the position or the location information of each entity.

2.2 Neighboring List in LTE Integrated System

In actual mobile systems, the network topology hardly changes so the neighboring lists are configured and managed manually by the operators based only on a geographic topology where base stations are fixed.

Otherwise, in an unplanned network like in the femtocellular, the topology of a system can change frequently, due to adding or remove arbitrary base stations HeNBs by users. Hence, it's very necessary for the network operator an automatic production and organization of neighboring lists. Otherwise, in the future network systems, every eNodeB or HeNB base station periodically gives a set of candidate kept in the list, in order to support UE's scanning process.

The existence of thousands of femtocells HeNBs inside a macrocell area and a vast number of targets HeNB applicants for macrocell to femtocell or even femtocell to femtocell handover generate interference problem, therefore we need a large neighboring list with several target HeNBs which may produce a signaling overhead and unnecessary handovers, therefore, resolving this issues may improve and optimize the performance of LTE network with large femtocells deployment.

Otherwise, if the neighboring list is unfinished and or inappropriate, the mobile user might handoff to an unwanted access point femtocell or even fails to handoff. Therefore, it is critical and very essential to create a good neighboring list for successful and efficient handover.

2.3 Novel Scheme for Neighboring Femtocell List

LTE femtocell-macrocell integrated network with large HeNB femtocells deployment still need optimization and organization because of the big number of the deployed HeNBs, so selecting the target HeNBs and defining the good one are the key for successful handover decision, especially for the hand-in and the inter-HeNB handovers. So a neighbor list contains the list of all UE's neighbor base stations. All eNodeB or HeNB stations included in the list should be periodically scanned with purpose of selecting the best candidates for the target HeNB, this list is provided to the UE by its serving base station.

Whenever an UE moves away from a HeNB or moves round the eNodeB zone, it receives signals from several base stations HeNB femtocells and from serving eNodeB macrocell. So minimizing the quantity of scanning and signal flux through the handover process is effective by reducing the size of the neighboring list in the integrated system.

However, a neighboring list in a system that use only the RSSI signal for selection will contain a great number of base stations which cause unnecessary scanning. Besides, lost some of the unseen HeNBs in the list causes the failure of handover process.

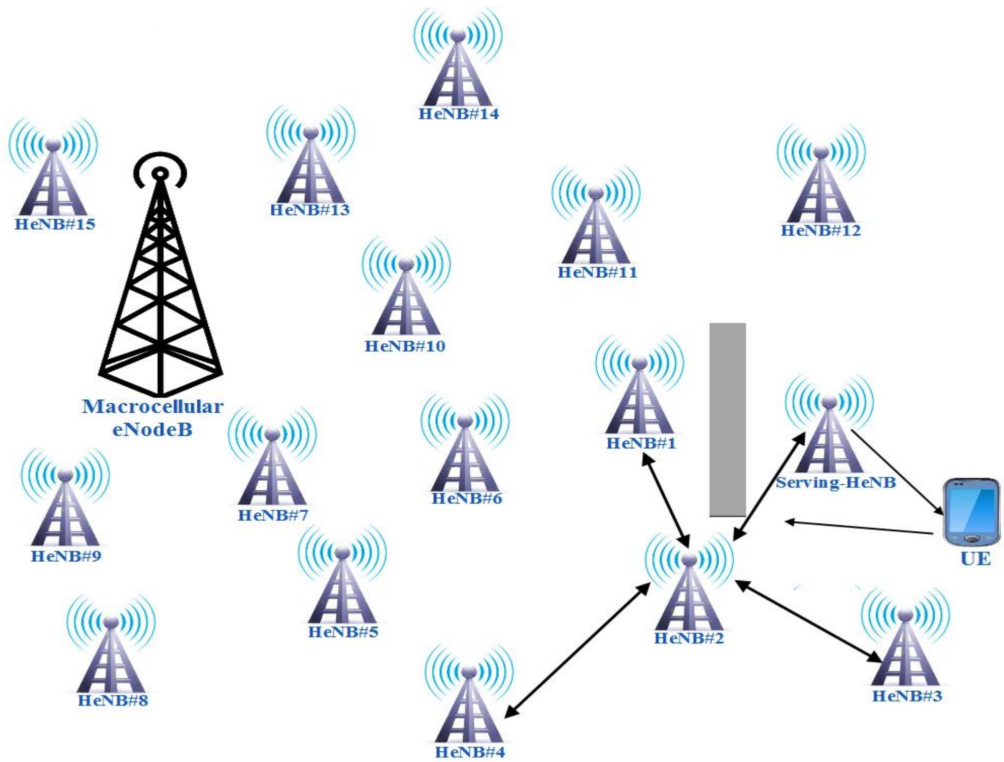

Figure 2. Large femtocell deployments where many hidden HeNBs with other HeNBs are set as neighboring femtocells

The figure 2 shows that the UE can't obtain enough signal level from the HeNB#1 since there is an obstacle a barrier, and the serving HeNB and HeNB#1 also cannot cooperate with each other. Therefore, a neighboring list built on the base of just the RSSI measurement does not contain the HeNB#1.

Therefore we need a certain connection between the serving HeNB and the HeNB#1, so by using the SON features, the base station HeNB#2 and HeNB#1 cooperate and synchronize with each other. The base stations HeNB#2 send the location of HeNB#1 to the serving HeNB, once getting this data, the neighboring list add the HeNB#1. Then, the UE can complete the procedure with HeNB#1, by using the cooperation between the serving HeNB and HeNB#1.Then, if the UE changes its position closer to HeNB#1 and receives enough level of signal, then the established signal from the serving HeNB goes under the limit level then the connection of UE is changed from the current HeNB to HeNB#1. The suggested scheme firstly considers the received signal RSSI level to generate the neighboring list.

In dense femtocell network, the HeNBs located and separated far away, can use the same frequency. The imbrication of two HeNBs does not use equivalent frequency to escape the interference.

Hence, for the inter-HeNB handover, the HeNBs that uses the same frequency as the serving HeNB are deleted from the initial neighboring list on the basis of the RSSI signal level.

In other hand, the neighboring list can added the unseen base station HeNB existing in the system, by using the coordination concept between neighboring HeNBs or between HeNBs and eNodeB macrocell.

To improve the performance of handover decision phase we optimize the neighboring femtocell list, so the figures 3 and 4 illustrate the flux mechanisms of the optimal neighboring femtocell list when the UE is connected with an HeNB, and when the UE is connected with an eNodeB macrocell respectively, where Nf and Nc present the entire number of HeNBs femtocells and eNodeB macrocells contained in the neighboring list. We make use of two threshold levels of signal for diagram of the flux mechanisms.

The first considered threshold is signal level S1 which presents the minimum level of signal RSSI that is necessary to identify the presence of a HeNB base station. The second signal level S2 considered is superior to S1; this latter is used to build up the neighboring list. The determination of the value S2 is based on the density of HeNBs. So by increasing the number of femtocells deployed in the network the value of S2 is increased systematically.

The kth base station HeNB is automatically included to the neighboring list if the signal level Si from the kth HeNB is bigger than or equivalent to the second threshold S2, of course after verifying the open-closed access system.

Initially all the base stations HeNBs from where the UE receives signals are considered to make and generate the neighboring list. Then, for those with the closed mode, all the non-available HeNBs are deleted from the first neighboring list.

Finding the nearest HeNBs for possible hondover is based on the frequency allocations criteria, otherwise finding the unseen base stations HeNBs is performed by the coordination among the neighboring HeNBs as well as between the HeNBs and eNodeB.

The hidden HeNBs are those who are very close to the serving base station and the received signals are inferior to S2. So the UE cannot receive enough signal level from these HeNBs or even no signal at all due to some obstacles between the UE and these HeNBs; while, these base stations are very near to the UE.

Therefore, adding these unseen base stations in the neighboring list minimize the chance that the UE fails to handover toward the target base station.

So to construct an optimal neighboring list we consider not only the RSSI signal level, but also other criteria like the frequency rate of the serving base station, and ith neighboring HeNB, then the information about the position of base station to optimize the list. In LTE network with large femtocell deployment, overlapped femtocells doesn't use the same frequency.

Therefore, in the inter-HeNB handover scenarios, we can remove the femtocells that use similar frequency as the current base station from the neighboring list, otherwise, for the hand-in handover scenarios, if the UE receives signals from two or more neighboring femtocells that use similar frequency, then the closer one is added to the base station of category 2. This category contains the base station femtocells with signal level RSSI less than S2 or the HeNBs with similar frequency as the serving base station, so generally the unseen femtocells are selected from category 2.

2.4 Handover Signaling Flux

The handover procedure permits for the user's to maintain their communication while they are moving in the network, it means keeping the mobile clients connected to their service network, even when these users roam from a network access point to another one, so switching seamlessly between femtocells and macrocells is a crucial issue for LTE integrated system.

The LTE system with large femtocells contain many criteria to satisfy for executing efficient handover, we have the signal level measurement, the SON features, generating an improved neighboring list, choosing an appropriate access network, handover decision and execution. Therefore, our proposed handover procedure for the LTE integrated network can minimize the handover interruption time so we tried to present a handover signaling flow that can offer reliable handover with minimum signaling overhead.

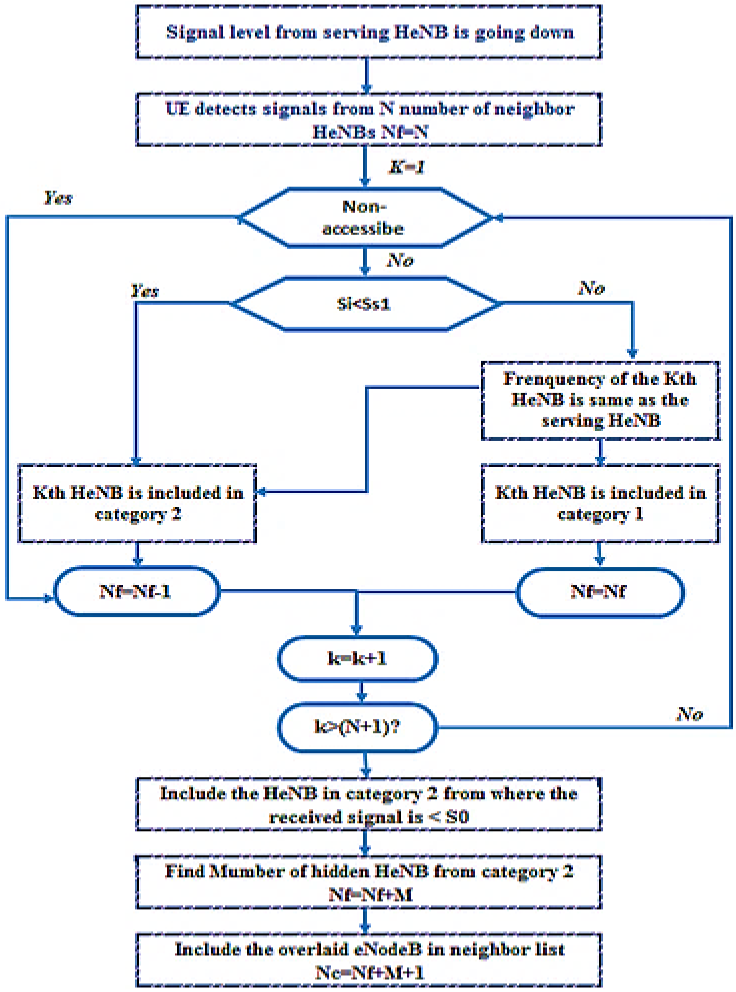

Figure 3. Flux mechanisms of the proposed neighboring list for handover when the UE is connected with a HeNB

2.4.1 LTE hand-in (Macrocell to Femtocell handover)

The hand-in handover is the most interesting process for femtocell network, it's the handover scenario where a user change the connection from the macrocell to femtocell, and it's a difficult procedure since there is thousands of possible targets HeNBs, in this scenario UE must choose the best target HeNB between many candidates. The Figure 5 presents the details flux mechanism for macrocell to femtocell handover in LTE integrated system.

When the UE detects a signal from HeNB femtocell it sends the measurement report to eNodeB base station, it include also the information about interference level.

The group of UE, macrocellular eNodeB, and neighboring HeNBs collaborate to make the SON configuration for generating an efficient neighboring list for the handover. Based on the pre-authenticated and received signal levels from the received measurement report message, the UE decides to handover to the target HeNB, the eNodeB send a handover request message to begin the handover procedures. The message is transferred from the serving eNodeB to target HeNB through the core network and HeNB-GW entity.

For the call admission control, the target HeNB checks the user's authorization and performs the admission control based on the quality of service QoS information, performing also the CAC, RRC, matches the interference level in serving and target femtocell zone coverage to admit a call, and then the HeNB replies for the handover request.

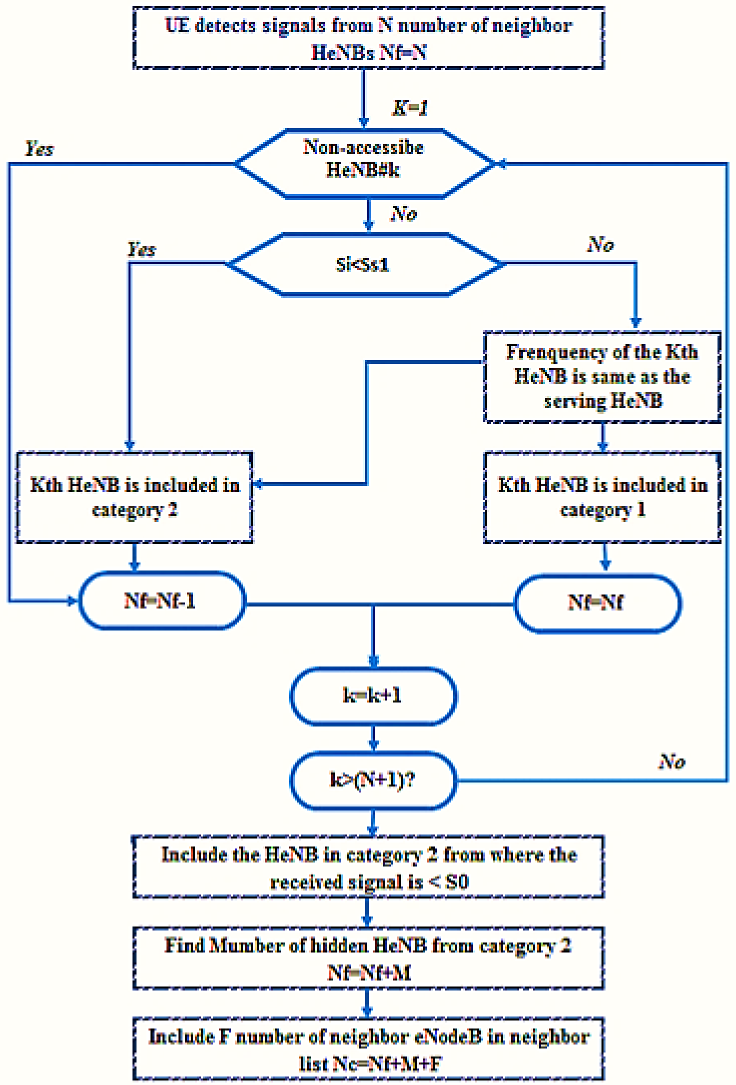

Figure 4. Flux mechanisms of the optimized neighboring list for handover when the user is attached with the serving eNodeB

Handover execution phase; on the execution part a new connection is established between the HeNB-GW and the target HeNB. The user re-established a link with the target HeNB, disconnected from old base station and synchronizes to the new one; so the UE access to the target base station after the synchronization.

The UE informs the serving eNodeB with a completion message that the UE already finished the handover and coordinated with the target HeNB, the packets are sent to the UE through the HeNB.

The handover completion phase; it's a confirmation of handover and pathway change, the S-GW (serving gateway) switches the path of downlink data to the target. For this, the S-GW exchanges message with the MME, the serving eNodeB release radio and control of related resources, when it receipt the release message. So the UE inform the serving-eNodeB that it's already completed the handover process by sending a complete message and coordinated with the target HeNB. Then, this latter can transmit the downlink packet data.

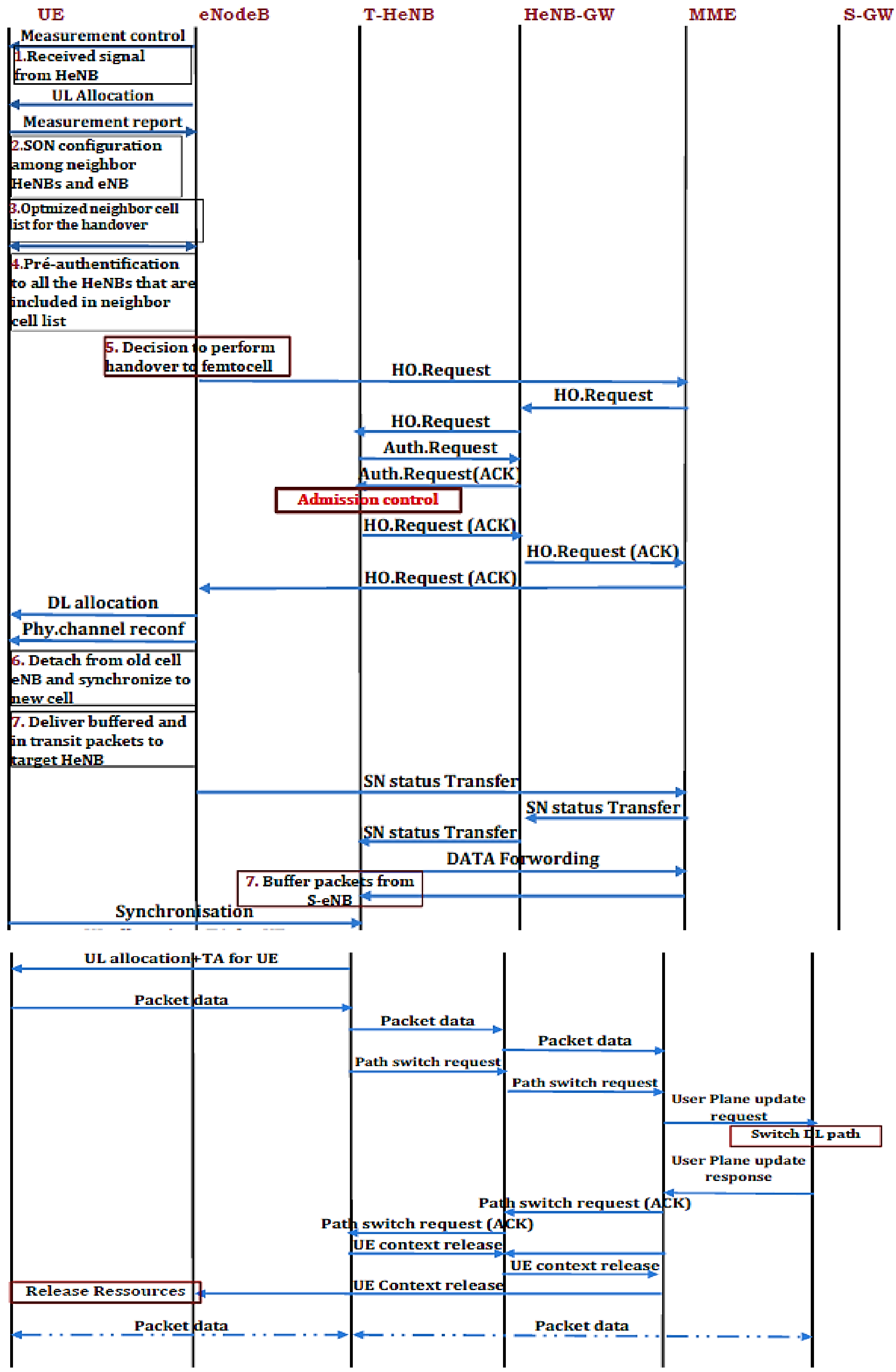

Figure 5. The signaling flux for LTE hand-in procedure

2.4.2 LTE hand-off (femtocell to macrocell handover)

The hand-off procedure is the handover of mobile user from femtocell to macrocell, it's much easier than the hand-in process since there is a single target the eNodeB base station. The signalling sequence and the flux of messages for the LTE hand-off procedure is corresponding to the LTE hand-in handover, the only difference is the nodes and the entities.

2.4.3 LTE Inter-HeNB (femtocell to femtocell handover)

The inter-HeNB handover is the interaction between two femtocells in the same macrocell network. The inter-HeNB is like the hand-in procedure, where several candidate targets HeNBs possible for handover, so when the UE move out the area of its serving HeNB, the UE needs to select the optimal target HeNB among many neighbor HeNBs, so the signaling call flux almost respect the same exchanged messages between the different entity as the hand-in handover procedure.

2.5 CAC Scheme for LTE Integrated System

The call admission control CAC have an essential role in developing and maximizing the utilization of resource for the LTE femtocell- macrocell integrated system, by managing and controlling the admission of different traffic calls especially inside the macrocellular networks.

The objective of suggesting a CAC scheme for LTE integrated system it's to transmit a maximum number of macrocell calls to be supported and handled in the femtocellular networks.

Three categories of calls in the system is considered in the call admission control policy, we have the newly arriving calls to the network, the calls that initially connected with the macrocell eNodeB, and finally we have the calls that are initially connected with the femtocell HeNBs.

To provide an efficient CAC scheme we suppose to accept a call in the system, using two threshold levels of signal SNIR T1 and T2.

The first level T1 presents the minimum level of signal required to connect a call to any HeNB femtocell, while the second threshold T2 is superior to T1. We assume that two different velocity category to be considered, low speed (0-30 km/h) and high speed (>30 km/h).

We make use of the QoS degradation approach of the quality of service adaptive multimedia traffic to accommodate hand-in and hand-out handover calls.

The Crelease is the current quality of service adaptive multimedia traffic in serving macrocell, the release quantity of bandwidth to receive the handover calls in the macrocell system.

This releasable quantity of quality of service is depending on the number of running quality of service and their maximum level of acceptable quality of service degradation and the total number of current calls in the macrocell system.

We assume that the Ɓr,m is the requested bandwidth by a call and the Ɓmin,m present the minimum reserved bandwidth for an appeal of traffic class m. so, to receive a call each of the mth class QoS adaptive calls can release a maximum quantity of bandwidth.

$$\mathcal{B}max,m = \mathcal{B}r,m - \mathcal{B}min,m \tag{1}$$

The accessible empty bandwidth $C_{available}$ in the macrocell area is:

$$Cavailable = C - Coccupied,m \tag{2}$$

Where C present the capacity of the bandwidth in the macrocell and $C_{occupied,m}$ is the employed bandwidth by the current macrocell calls.

3. Results & Discussion

3.1 Newly Arriving Calls

The Figure 6 illustrates the call admission control CAC strategy for newly arriving calls. When a new call reaches the network, the call admission control firstly verifies the availability of the HeNB coverage. If HeNB femtocell coverage is available, so a femtocell base station is the first choice to connect a call.

If the signal level T2 is satisfied, and the moving user is with a low velocity not with high speed to avoid the ping ponging effect and the resources in the HeNB are available, therefore, the HeNB femtocell accepts a new arriving call, the $SNIR_{T,h}$ is the received signal level of the target HeNB. Otherwise, if all this conditions are not complete, then the call attempts to attach with the serving eNodeB macrocell.

In other hand, the macrocell system does not permit the quality of service degradation rule to receive any new arriving calls. A appeal of mth class traffic is disallowed if the needed bandwidth Ɓr,m is not available in the serving eNodeB.

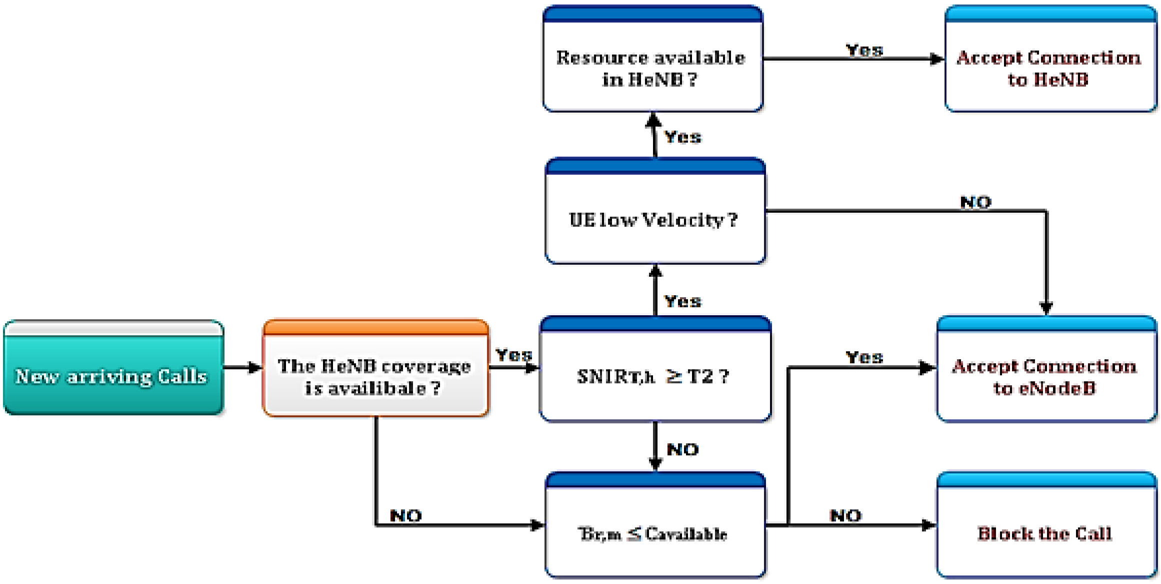

Figure 6. The CAC scheme for new arriving calls

3.2 Calls that are Originally Connected with the eNodeB

The Figure 7 presents the call admission control strategy for the calls that are initially associated with the eNodeB.

Once the mobile UE detects a signal from a HeNB, the CAC scheme verify the established $SNIR_{T,h}$ level for the target HeNB. A call connected to eNodeB is transferred to the HeNB if the $SNIR_{T,h}$ equal to the minimum level T2 or the actual received SNIR level of the eNodeB, the $SNIR_{T,eN}$ level is less than or equal to $SNIR_{T,h}$, when one of this conditions is satisfied in addition to check the speed status parameter of the mobile user as low velocity or not, then it checks the availability of the resources in the HeNB destination. We choose to use the higher level of signal T2 to evade some redundant hand-in handovers.

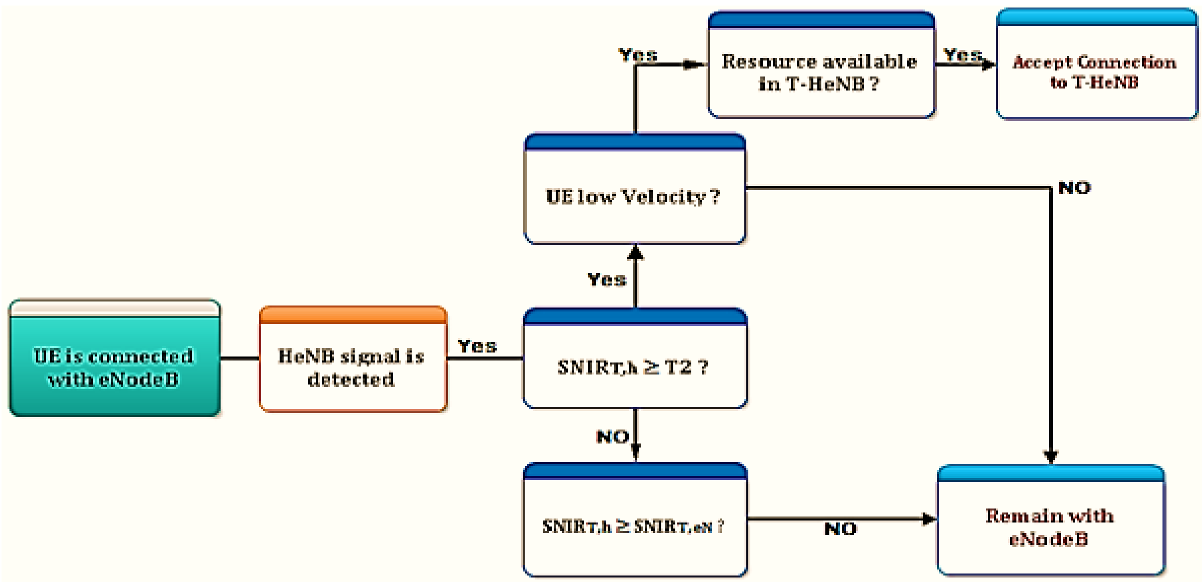

Figure 7. The CAC scheme Calls that are originally connected with the eNodeB

3.3 Calls that are Originally Connected with the HeNBs

The figure 8 illustrates the CAC strategy for calls that are initially attached with the HeNB. The inter-HeNB and hand-off handover calls are managed by this strategy.

The UE starts a handover to other HeNBs or a serving eNodeB, when the signal level from the serving-HeNB is decreasing. When another target HeNB is not accessible for transfer, If a free resource in the macrocell system is not sufficient to accept the call, the call admission control scheme permits the liberation of some bandwidth from the current calls by degrading their quality of service level, and also authorizes the decrease of the necessary bandwidth for a handover call request, so the call is attached with the macrocell.

The system permits a maximal $B_{max,m}$ quantity of bandwidth decrease for an current call or a demanded handover call. Hence, the system raises the number of calls accepted as well as decreases the probability of dropping a handover call.

A call is dropped if the minimal necessary bandwidth $B_{min,m}$ is not accessible in the macrocell system after liberating of some bandwidth from the current calls. If the received $SNIR_{T,h}$ level of the target HeNB is superior than or equal to threshold T2 and the moving user is with low speed, then the UE first tries to connect with the HeNB.

In other hand, if a received $SNIR_{T,h}$ of the target HeNB is in between T1 and T2, and the moving user is with higher speed, then the UE firstly tries to attach with the eNodeB. Otherwise, if resources are not accessible in the macrocell network or moving user is with a low speed, the UE attempts to handover to the target HeNB, even if the received $SNIR_{T,h}$ of the target HeNB is inferior than T2. Otherwise, the quality of service degradation rule is only valid when the received $SNIR_{T,h}$ of the target HeNB is inferior than T1 or resources in the target HeNB are not accessible.

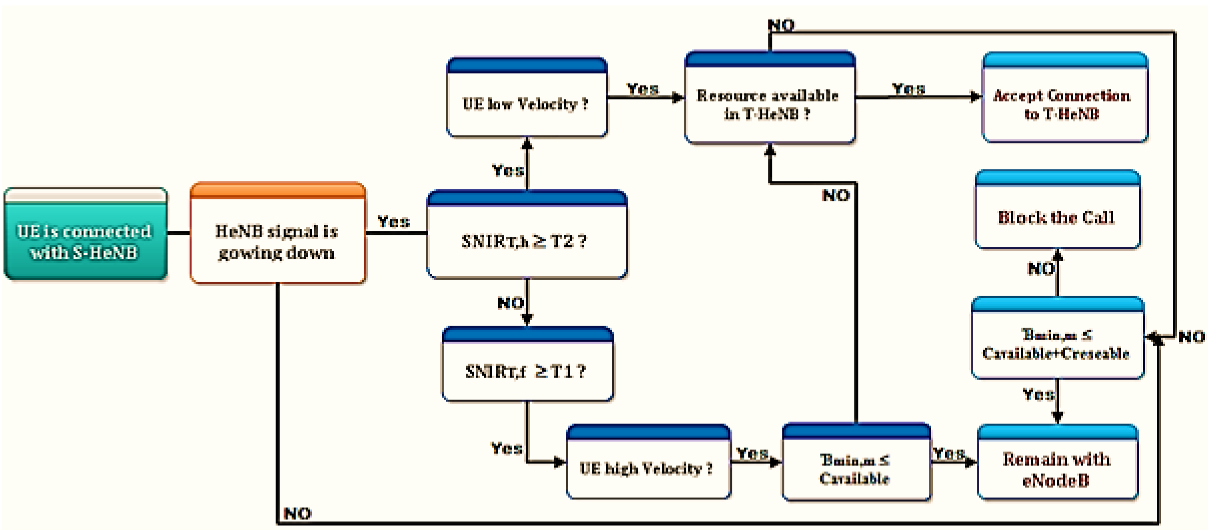

Figure 8. The calls that are originally connected with the HeNBs

3.4 Reducing the Unnecessary Handover

The mobile users continually move round the femtocell zone, so frequent and redundant handover is a big issue in LTE integrated system. A UE with high velocity gives two times unnecessary handovers owing to the frequent movement from an eNodeB base station to a HeNB and again from this latter to the eNodeB. In wireless networks, the recurrent and redundant handovers decrease the end-to-end quality of service level and also decrease the system capacity. So, the reducing this handovers is crucial for the LTE integrated system.

When a UE is attached with an eNodeB base station, it detects a change of signal level received from a HeNB because of the movement of UE.

In LTE integrated system, a simply unique handover decisions strategy is not enough to develop the performance of the system, so we need an optimized call admission control scheme. The call arriving rate and the handover call management is different in femtocellular system. In LTE integrated networks, the calls arrived, are the newly arriving calls, the calls transferred from macrocell to femtocell, and also the calls transmitted from femtocell to femtocell, the handover calls is divided into two categories, the first one is for the target HeNB with a signal level higher or equal to T2, the other categories is when the signal level is between T1 and T2 and these calls are rejected by the eNodeB.

We define μ_m (μ_f) as the channel release rate of the macrocell (femtocell), the $1/\mu$, $1/\mu_m$, and $1/\eta_f$ present the average call duration (exponentially distributed), the average cell dwell time for the macrocell (exponentially distributed), and the average cell dwell time for the femtocell (exponentially distributed), respectively.

For the numerical results the average call duration time ($1/\mu$) considering all calls is set to 120s, average cell dwell time $1/\eta_f$ for the femtocell 360s, and average cell dwell time $1/\mu_m$ for the macrocell 240s.

The hand-off handover calls are divided into two types, the calls that have directly connected with the eNodeB macrocell, and calls that have firstly arrived to femtocells, but are not authorized to access the femtocells owing to late of resources or poor signal level.

In LTE integrated system, when the number of deployed femtocells increases, also the average channel release rate increase, and so more users are transferred to be managed by femtocells.

The average channel release rates for the femtocell and the macrocell layer are calculated as follows.

For the macrocell layer is:

$$\mu_m=\eta_m\left(\sqrt{n}+1\right)+\mu \tag{3}$$

Where for the femtocell layer, it is

$$\mu_f=\eta_f+\mu \tag{4}$$

In LTE femtocell-macrocell integrated network, several elements can determine the probability of handover such as the cellule size, the average period of call, and the average user speed. Furthermore, the probabilities of handover from a HeNB to another one also depend on the deployed number of HeNBs base stations and the average size of femtocell coverage zone. Therefore, we have $P_{h,mm}$, $P_{h,mf}$, $P_{h,ff}$, and $P_{h,fm}$ are the inter-eNodeB handover probability, hand-in handover probability, inter-HeNB handover probability, and hand-off handover probability, respectively.

$$P_{h,mm}=\frac{\eta_m}{\eta_m+\mu} \tag{5}$$

$$P_{h,ff}=\left(n-1\right)\left(\frac{r_f}{r_m}\right)^2\frac{\eta}{\eta_f+\mu} \tag{6}$$

$$P_{h,fm}=[1-n\left(\frac{r_f}{r_m}\right)^2]\frac{\eta_f}{\eta_f+\mu} \tag{7}$$

$$P_{h,mf}=n\left(\frac{r_f}{r_m}\right)^2]\frac{\eta_m\sqrt{n}}{\eta_m\sqrt{n}+\mu} \tag{8}$$

The figure 9 shows that the LTE femtocell-macrocell integrated network raises the macrocell channel release rate it means an increased load transfer rate from the macrocell to the femtocell networks.

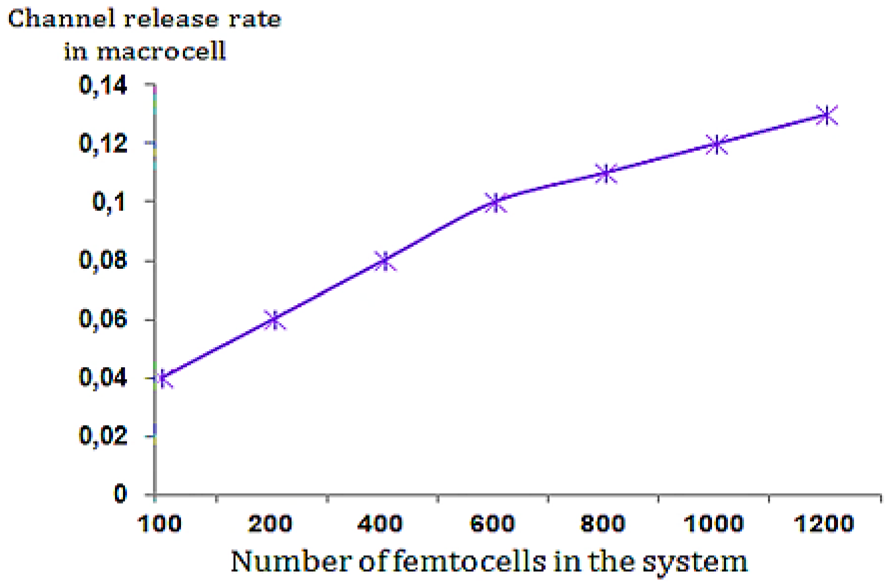

Figure 9. Channel release rate in a serving macrocellular network

The figure 10 presents the effect of increasing the number of the HeNB base stations within an LTE macrocellular network onto different handover probabilities.

The inter-HeNB handover and the hand-in handover probabilities are significantly increased, when the quantity of deployed HeNBs increases. As well, the hand-off handover probability is very high.

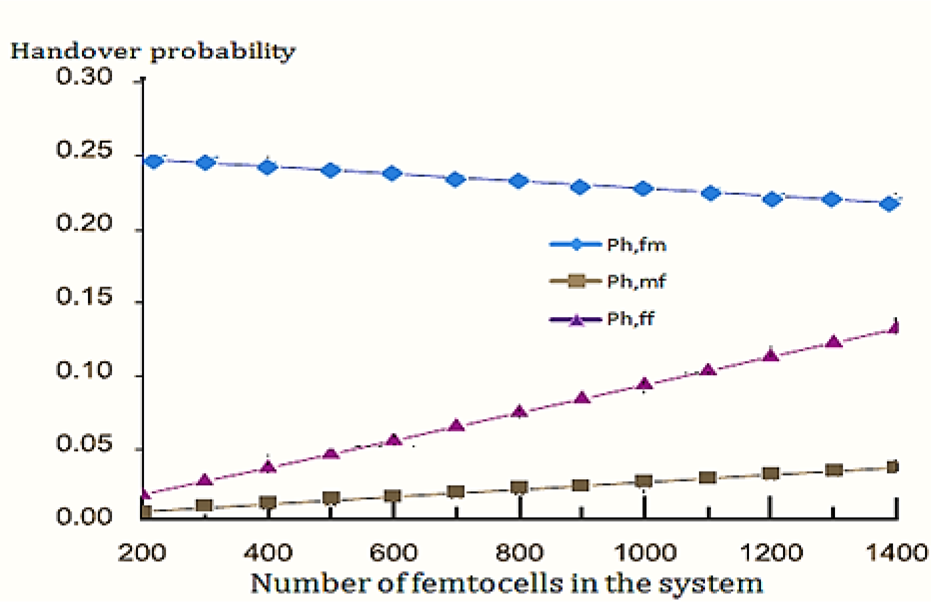

Figure 10. Handover probabilities with the increased number of femtocells

4. Conclusion

Femtocell is the recent technology studied by the mobile operators due to its potential benefits and advantages, the essential advantage of femtocells is possibility to discharge the macrocells.

The femtocells access point offer a small, low price, low power with high QoS network access for indoor users, and at the same time decreasing the load on the entire system and significantly improve the indoor coverage, however, the control of handover call is one of the challenging problems for an efficient deployment of femtocells.

The LTE integrated system is the optimal solution for the upcoming mobile networks, the mobility management of femtocellular with macrocellular networks presents the important part for the effective deployment of the femtocell technology, offering for LTE integrated system seamless and fast handover, minimizing unnecessary handover, and with a minimum number of signaling during handover.

But there are still hard technical challenges to be studied as the optimization of the handover and interference management, extend the time spent by users attached to the femtocells…but a whole solution for the mobility management in integrated systems is still an open research subject.

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