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Self-Organizing Comprehensive Handover Strategy for Multi-Tier LTE-Advanced Heterogeneous Networks

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Abstract

LTE-Advanced was introduced as real 4G with its new features and additional functions, satisfying the growing demands of quality and network coverage for the network operators' subscribers. The term muti-tier has also being recently used with respect to the heterogeneity of the network by applying the various sub-network cooperative systems and functionalities with self-organizing capabilities. Using indoor short-range low-power cellular base stations e.g. femtocells, in cooperation with existing long-range macrocells are considered as the key technical challenge of this multi-tier configuration. Furthermore shortage of network spectrum is a major concern for network operators which forces them to spend additional attentions to overcome the degradation in performance and quality of services in 4G HetNets. This research investigates handover between the different layers of a heterogeneous LTE-Advanced system, as a critical attribute to plan the best way of interactive coordination within the network for the proposed HetNet. The proposed comprehensive handover algorithm takes multiple factors in both handover sensing and decision stages, based on signal power reception, resource availability and handover optimization, as well as prioritization among macro and femto stations, to obtain maximum signal quality while avoiding unnecessary handovers.

Keywords

Handover, Interference Mitigation, HetNet, Self-Organizing, Femtocell, Macrocell, LTE-Advanced

I. Introduction

As a critical step towards improved network capacity and coverage, LTE-Advanced (LTE-A) was recently standardized in 3GPP new releases and approved by ITU and IMT-Advanced and is now considered as a true 4G system. Two important requirements of capacity and quality of network services are considered as the main objectives of network design and manufacture in telecommunication standards and networks, which have received the highest priority in recent upgrades of LTE-A systems [1], [2]. The peak data rate of 1 Gbit/sec, realizing 100 Mbps and 50 Mbps downlink and uplink rates, respectively; aided by MIMO and OFDM techniques, as well as network cooperative plans are mentioned as added values of these new releases. Capacity and quality of service in the network should also be considered in network design by planning to reduce the latency of packet transmission from the server to the clients. The resultant capacity and quality of service in the network are highly affected by growing demand and therefore appropriate solutions are required to measure and manage the spectral efficiency of the network. On the other hand, self-organizing methods have recently been investigated as reconfigurable technology to improve the spectrum efficiency for the wireless access technologies, such as LTE and LTE-A. Self-organizing strategy extracts planned coordination and interactions between network parts within its diverse stages, leading to a self-aware and demand-based network with capability of self-correction to increase network efficiency, while taking into account the end-to-end goals [3]. Due to the big demands of the wireless access and applications, the available unlicensed spectrum is reaching its limits and therefore the intelligent use of spectrum is essential to avoid latency and other difficulties in broadband communications such as congestion. However network heterogeneity could alleviate the discussed difficulties in capacity and quality of service by the integration of various sub-networks [4], [5], [6], e.g. marcocell, picocell, femtocell, relay nodes, etc. The multi-tier deployment in modern networks is considered as an advantageous way to reach heterogeneity in networks, as depicted in Figure 1.

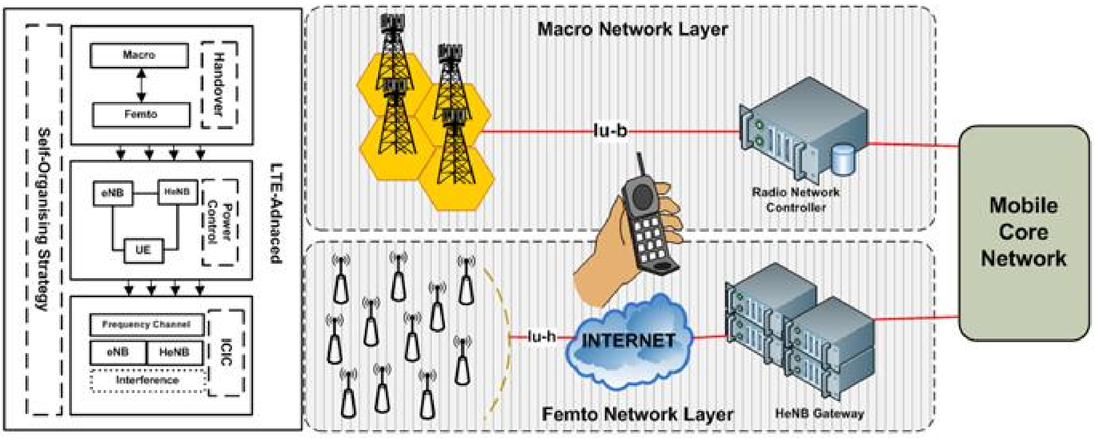
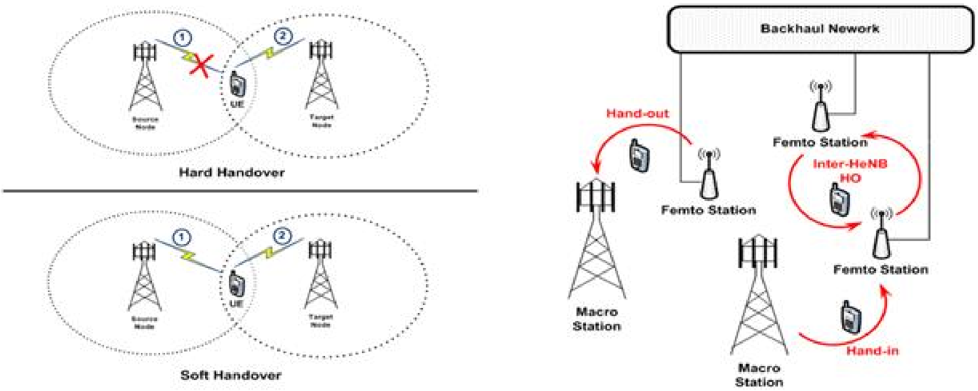


Figure 1 Multi-tier network deployment in heterogeneous networks

As explained briefly in the abstract, using of multi-tier structure in networks also brings some new challenges, despite its advantages in improved capacity and quality of service. The time and conditions for handover [7], [8], the transmission power configuration for various transmitter types, inter-cell interference, etc. are examples of those challenges [9]. This research presents a novel comprehensive handover strategy for the proposed multi-tier network construction in LTE-A, to facilitate mobile users' movements between general and sub-general network transmitters. It makes critical enhancements to the existing LTE networks, which improves cellular interference and spectrum usage.

Handover Classifications:
Handover can be classified as inter-cell and intra-cell handover. In inter-cell handover the Source and Target nodes are located on different cells, even if they are allocated to the same cell site, whereas in intra-cell handover both the Source and Target nodes belong to the same cell, and therefore the cell is not changed during the handover process.
In other classifications, handover is classified as hard handover and soft handover. In hard handover (break-before-make) the channel in the Source Node is completely released first, and then the channel in the Target node is engaged. Therefore the connection of the User Equipment (UE) and the Source node is broken before or exactly when the new connection to the Target node is made. Hard handover is considered as an Event during the ongoing communication and requires the least processing by the network providing system. On the other hand, in soft handover (make-before-break) the channel in the Source node continues to be used in parallel with the new connection to the Target node. Therefore, the connection to the Target node is established for a while before the connection to the Source channel is fully broken. The soft handover is considered as a State during the ongoing communication rather than an Event. There can also be more than two parallel connections and the used signals could also be combined to produce a stronger signal for transmission, either in downlink, uplink paths or both depending on what is most advantageous. Soft handovers are possible only when the handover cells have a single cell site. Also handover could be classified depending on the type of Target and Source nodes, as shown in Figure 2.



(a) **(b)**

Figure 2 (a) Definition between soft and hard handovers, (b) Different handover directions among macro and femto

II. Related Work

In [10] an efficient multi-objective handover solution is proposed for LTE cellular systems. The proposed solution considers different parameters e.g. available bandwidth and signal strength in the selection of the optimal target cell. This proposed multi-objective handover scheme results in a considerable improvement in the session blocking rates, handover latency, session queuing delay, and throughput during handover. Femtocells offload large amount of traffic from the macrocellular network in cases of dense deployment of femto applications, but the handover among macro and femto parts of the network presents a key challenge.

To plan handover management in high-dense networks, research [11] considers intelligent femto/macro network architecture as the main contribution. The neighbour cell list with a minimum number of femtocells and effective call admission control (CAC) are considered by proposing a novel algorithm for the handover. The algorithm aims to create a neighbour cell list with a minimum, but appropriate number of cells for handover, as well as novel handover procedure and traffic model for macro/femto networks. Results show that the proposed CAC could be effective in handling of various calls.

Research in [12] addresses two major challenges of handover, one is signal measurement by UEs, whether located in or out of range, and the second is the large number of idle femtocells as a result of having a dense deployment of macrocell in many urban areas. The research proposes an efficient measurement procedure and appropriate solutions for the two above mentioned challenges. Seamless handover is planned and simulated in [13] by reactively multicasting the data to both the source and target cells after the handover is actually initiated, which results in a reduction in the downlink service interruption time, as well as avoiding the packet loss compared to the standard 3GPP, with only limited extra requirements.

Newly proposed 3-D Markov Chain model for indoor applications and LTE femtocell are also discussed in [14], [15] respectively, which are required to define priority in the handover algorithm. On the other hand, different mobility patterns and dynamic network conditions might cause challenging situation for mobile users, despite femtocells capability of providing services in shadowed areas by cell coverage enhancements.

Research [10] introduces the unnecessary handovers reductions based on the Call Admission Control (CAC) Mechanism between WiMAX and femtocells. The femtocell capability of providing services in shadowed areas of WiMAX cell coverage is used to relieve the main traffic from the macro network, as well as reducing the costs for the network operators, service quality in indoor environments and capacity increase.

III. Comprehensive Handover Algorithm

The proposed comprehensive handover strategy is based on a two-way handover for both macro-femto and femto-macro sides and the general processes of the handover sensing and decision are made in the source node, either eNB or HeNB. Since having no direct interface between macro and femto stations, the communications between eNB and HeNB are implemented through the mobility management entity (MME) and gateways. The table of abbreviations and the proposed comprehensive handover process diagram are depicted on Figure 3. The focus of this work is to propose novel algorithms for both the sensing and decision process within the handover model. The proposed algorithms is based on different steps, called checks, which confirm the algorithm to continue with the handover process, or return back to the beginning on the algorithm.

MC: Measurement Control	RANAP: Radio Access Network Application Part
MR: Measurement Report	RANAP RD: RANAP Relocation Detect
HOR: Handover Request	RANAP RC: RANAP Relocation Release
HOA: Handover Acknowledgment	UE CR: UE Context Release
HCM: Handover Command	ULA: Uplink Allocation
PCR: Physical Channel Reconfiguration	DLA: Downlink Allocation
PCC: Physical Channel Complete	Determine: Determine the Target eNB/HeNB
$CINR_T$: CINR Target	Decision: The handover decision
$CINR_S$: CINR Source	Detach: Detach from the source eNB/HeNB
HCN: Handover Confirm	Release: Release the sources
ST: Status Transfer	U-Plane UR: User Plane Update Request
PDF: Packet Data Forwarding	U-Plane UA: User Plane Update Acknowledge
PSR: Path Switch Request	RSRP: Reference Signal Received Power
PSA: Path Switch Acknowledgment	RSRQ: Reference Signal Received Quality
PD: Packet Data	RSSI: Receive Strength Signal Indicator

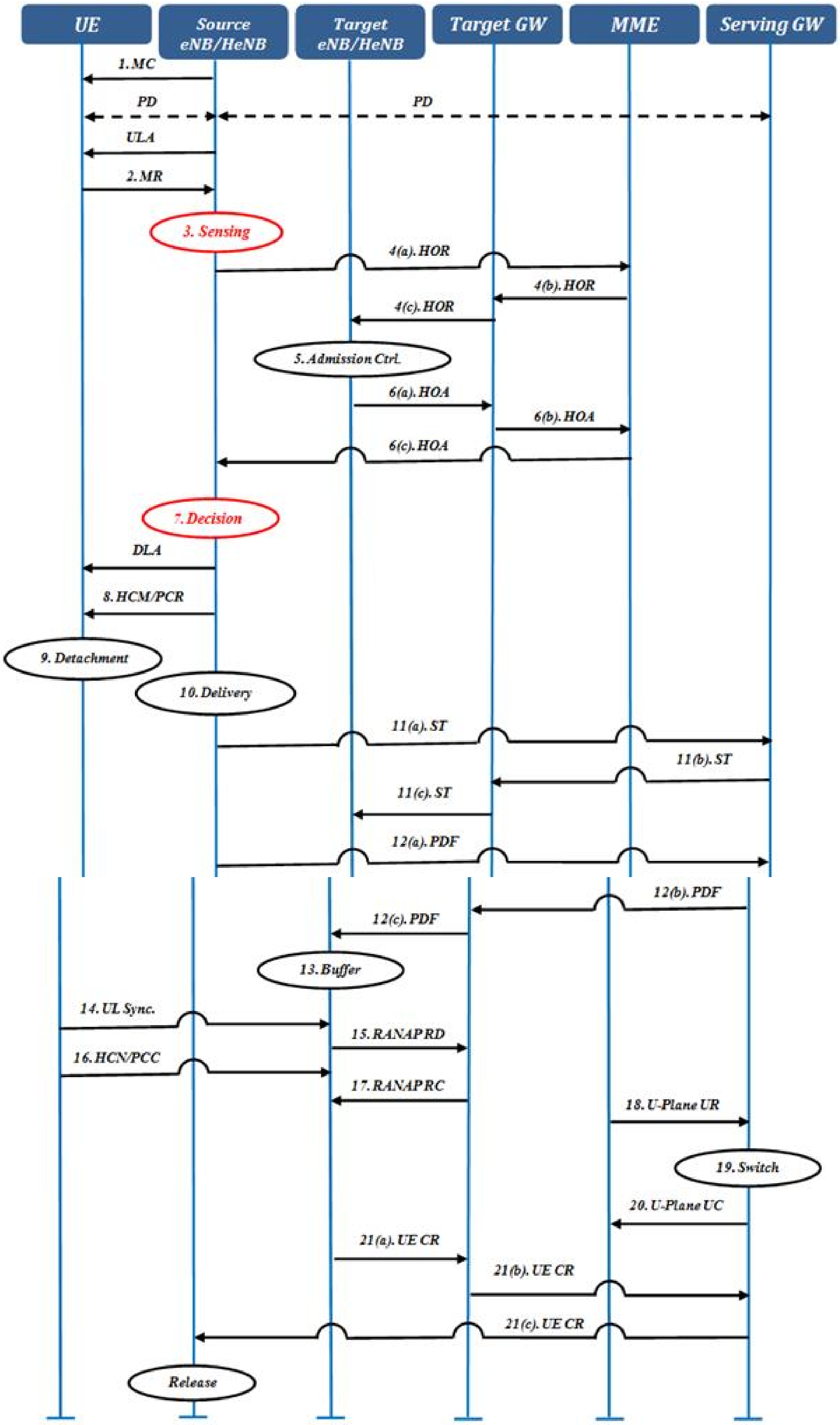


Figure 3 Comprehensive handover algorithm process model

IV. Technical Considerations

Most of the related works in handover (HO) formulation for LTE systems consider one or two statistics to be checked on handover decision step, but this work follows a more comprehensive strategy to consider more parameters than beforehand. For this reason, some considerations have to be taken into account. As the first consideration, blocking a handover call in the system is not dropping that call. Also the handover from femto to macro station (outbound handover) is not as complex as the handover from macro to femto (inbound handover), because there is no other option rather than a handover to a macro station each time an outbound handover is being made. In complete spectrum sharing, the total spectrum band is shared by macro and femto stations, and in open access mode the femto stations are free to be arbitrarily used by any users. This expands the network capabilities and coverage with an inexpensive solution for the network operators. In the proposed algorithm, it is assumed that a UE with a new session which is waiting in the HO queue does not move from one eNB to another.

The considered total channel bandwidth is 20MHz up to 100 MHz, which contain 100 and 500 resource blocks (RBs) respectively. RB is the smallest time-frequency resource consisting of 12 subcarriers which can be allocated to a UE. Significant reduction in blocking probability and queuing delay are anticipated when using this handover operation, compared to the existing handover mechanisms. Figure 4 depicts the communication objects and entities used for the HO process [9].

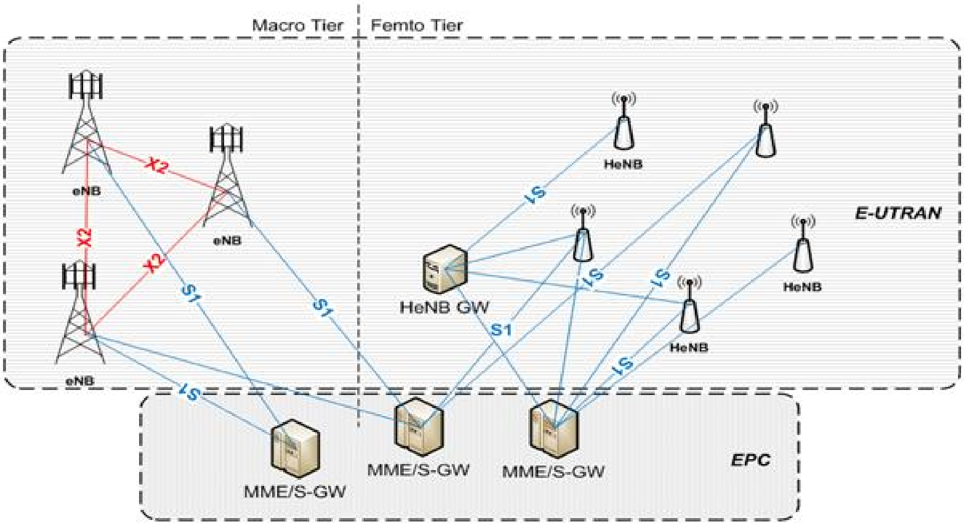


Figure 4 Macro-femto objects and entities to be used in handover process

The Reference Signal Received Power (RSRP) and Quality (RSRQ) values are measured by the UE and reported via Measurement Report (MR) to the Source eNB/HeNB, and the available bandwidth (RBs) is reported by Target eNB/HeNB via Handover Acknowledgment (HA) to the Source eNB/HeNB. The proposed comprehensive handover algorithm is enhanced by using multiple checks to firstly avoid unnecessary handovers, and secondly prioritize low-power femto stations over high-power macro base stations, which significantly increase the QoS over the LTE-A network. The algorithm mainly focuses on handover sensing and decision processes. The proposed multi-objective handover algorithm initially considers the signal received power and quality as the handover sensing process, followed by bandwidth availability check, user residence check, and femto over macro priority check, and incorporated within the handover decision process. The novelties of this algorithm consist of both its sensing and decision processes, as well as its unique extra checks. The internal links and interfaces make the communications between gateways, mobility management and core network, as shown on Figure 5.

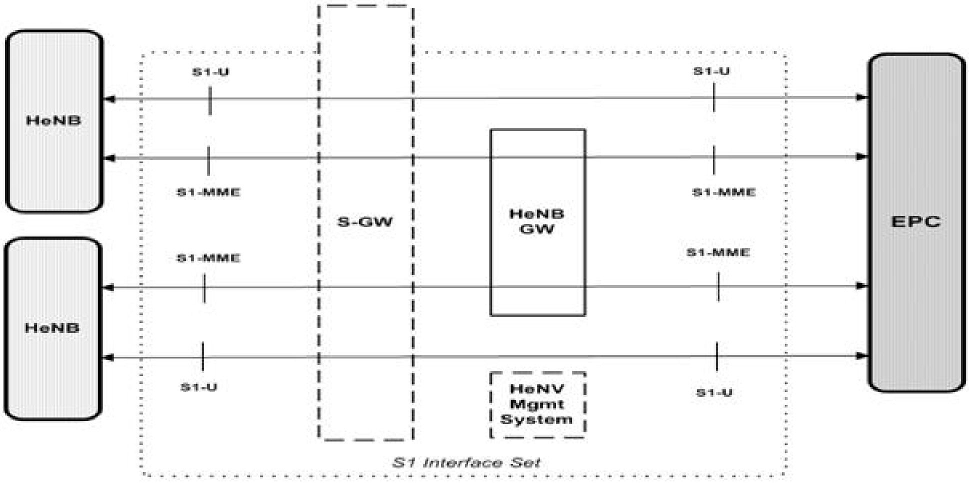


Figure 5 Macro-Femto internal interfaces to be used in handover process

V. System Model

A. Sensing Process:

The reference signal received power (RSRP) is measured and reported by UE and includes antenna gain, pathloss, log-normal shadowing, and fast fading, which are averaged over all the reference symbols within the measurement bandwidth. Considering P as downlink received power and $G_{k,j}$ as estimated channel gain for the j^{th} symbol of the k^{th} eNodeB, the downlink-received RSRP from the k^{th} cell is estimated as Equation (1) [10]:

$$\mathrm{RSRP_k} = P \sum_{j} G_{\mathrm{k,j}} \qquad (in\ which\ j\epsilon all\ symbols) \qquad (1)$$

The receive strength signal indicator (RSSI) and RSRQ are also calculated based on the proposed algorithm definitions by the simulation platform. RSSI comprises the linear average of the total received power (in W), which is only observed in OFDM symbols containing reference symbols, and is calculated by the simulation source codes. The RSRQ value also is calculated for N number of RBs of the E-UTRA carrier RSSI measurement bandwidth as Equation (2):

$$\mathrm{RSRQ} = N \times \frac{\mathrm{RSRP}}{\mathrm{RSSI}} \qquad (2)$$

Since the RSSI includes the noise generated in the receiver and also thermal noise, so RSRQ expresses the relation between signal and noise [16].

The simulator uses both the RSRP and RSRQ values to calculate a parameter called as *Cell Preference Value*. The calculation process of the Cell Performance Value is then followed by a condition test, which if it is between 0 and 100 (inclusive), allows the candidate to be added to the list of handovers. The sub-algorithm flowcharts for handover sensing process are depicted on Figure 6.

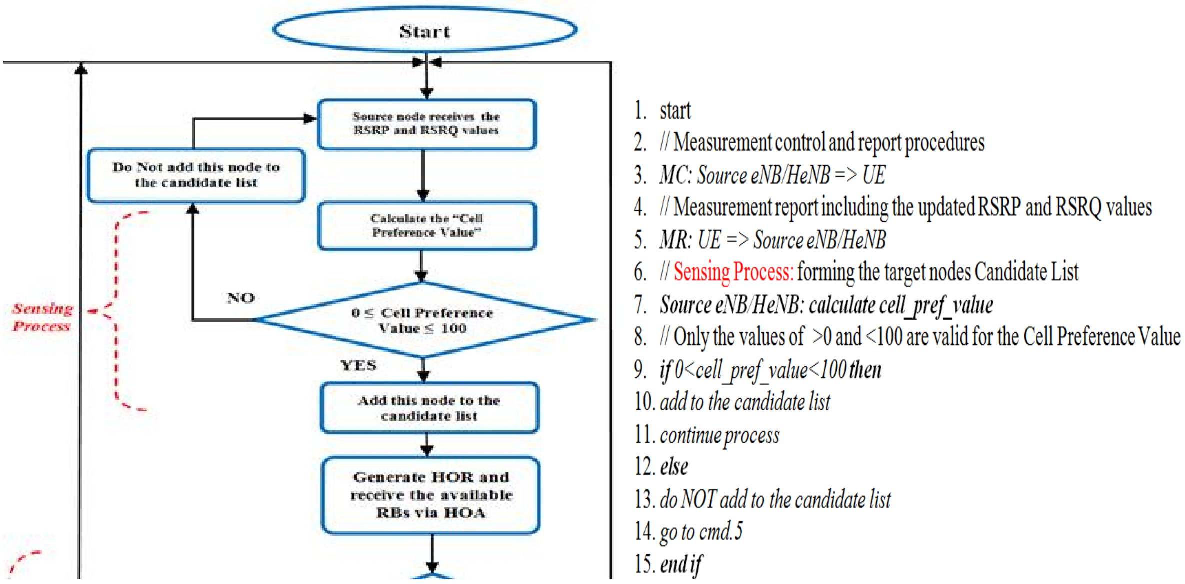


Figure 6 Handover sensing process sub-algorithm flowcharts and pseudo code

B. Decision Process:

C.1. Resource Availability check:

The first assessment parameter of the handover decision process is to check the available radio resources or wireless bandwidth in the target node, and if the resource availability satisfied, the process qualifies to start the handover optimization check (Figure 7). This test is computed by the RBs available in the target node, which results in the target node capable of offering the maximum available resources being selected.

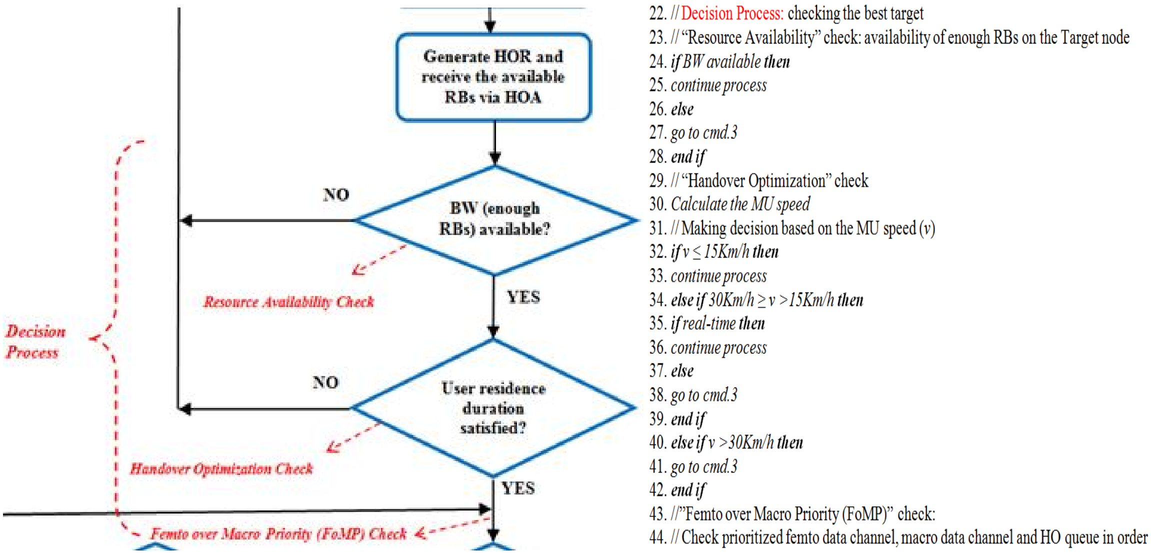


Figure 7 Resource availability and handover optimization checks

The fraction of the total available RBs is mathematically calculated by Equation (3).

$$g_k(\eta, \beta) = \frac{\phi - \sum_{i=1}^{\eta} \beta_i}{\phi} \qquad (3)$$

where $\boldsymbol{\phi}$ is the total number of RBs of the target node, β_i is the RBs consumed by the i^{th} UE, and η represents the number of active UEs in the k^{th} Target node. The distribution of the RBs, given by$\beta = \sum_{i=1}^{\eta} \beta_i$, could vary for each different application through the network, e.g. voice calls, data transmission, etc. Furthermore, the total number of RBs ($\boldsymbol{\phi}$) is fixed for any node across the entire frequency for a particular channel bandwidth, and every eNodeB or HeNodeB allocates a portion of these RBs between different users depending on its current channel conditions and cell-load [10].

C.2. Handover Optimization check

Although having low power capabilities, femtocell indoor application provides low range and limited coverage for the mobile user, which could result in a notable number of unnecessary handovers in some circumstances. As a very possible scenario, a high speed UE might possibly enter the cell and be covered by multiple femto stations, each for a short period of time, which causes multiple successive unnecessary handovers and therefore the noticeable reduction in quality of service. Therefore, minimizing the number of unnecessary handovers is considered as a dominant objective for the novel handover strategy. For this reason, a new call admission control (CAC) mechanism is proposed as part of the handover decision process. The critical parameters that are considered in this check include the expected UE dwell time in Femto coverage area, by considering the UE speed (in Km/h), in cooperation with the signal quality handover checks, to minimize any unnecessary handovers. Hence, the pre-defined UE state is initially defined in Table 1 [17], [18].

Table 1
Pre-defined UE residence states for different speed ranges

UE Residence State	UE Speed (Km/h)
Low Speed	*0 to 15*
Medium Speed	*15 to 30*
High Speed	*> 30*

The calculations for the optimized handover check need more complexity to calculate the UE speed and consider the appropriate UE residence state, which the process is designated after the resource availability check. The flowchart for the handover optimization check, which is based on the defined speed ranges, is depicted on Figure 8.

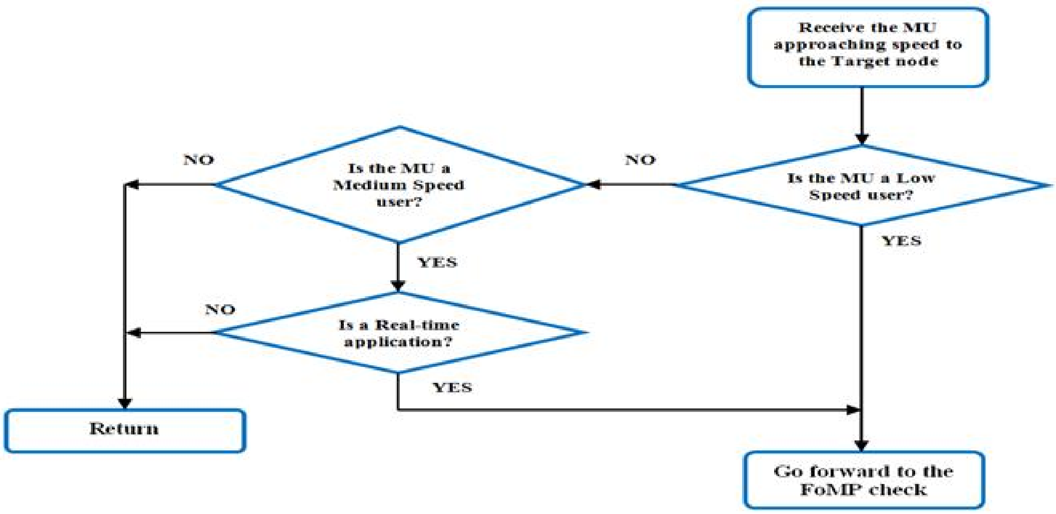


Figure 8 Handover optimization check flowchart

C.3. Femto over Macro Priority (FoMP) check

As a technical comparison between the central macro and supportive femto applications, femto services deliver lower power requirements, higher quality of signal, and also encouraging cost of services, which altogether make the use of femto stations a priority over the macro. Therefore, as the final stage of handover decision process, macro-femto handover (hand-in) is considered to have priority for handing over to a macro station (hand-out) in this algorithm (Figure 9).

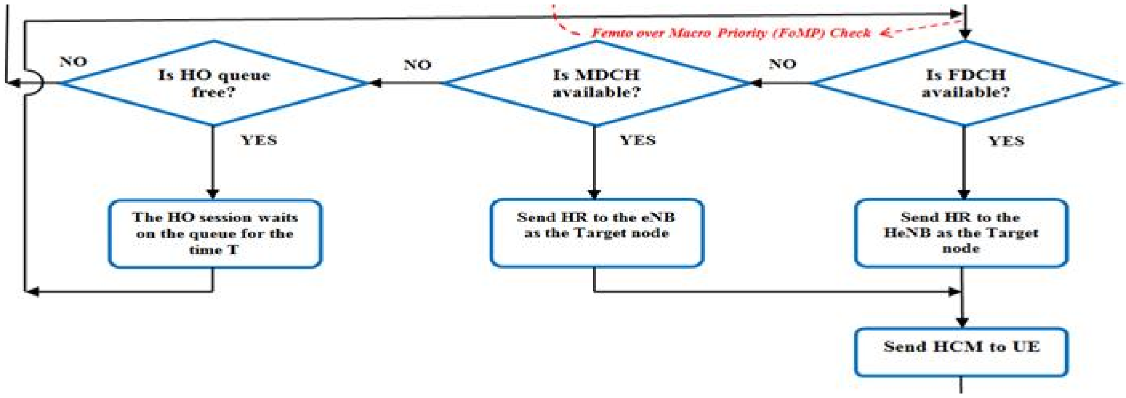


Figure 9 Femto over Micro Priority (FoMP) check sub-algorithm flowcharts

To characterize the behaviour of the macro and femto channel allocation within the handover process to select the best available station, the handover transitions and probabilities estimations are introduced using the three dimensional (3D) Discrete Markov Chain [10]. In this regard, the potential target node is selected from the nearby femto nodes, if available [19]. If not, the target node is selected from the available macro stations to enhance the signal reception. The 3D Markov Chain is defined as shown on Equation (4).

$$(m, n, b), 0 \leq m \leq M, 0 \leq n \leq N, 0 \leq b \leq B \tag{4}$$

The major parameters and symbols are described as in Table 2.

Table 2
Major parameters and definitions for 3D Markov Chain

Symbol	Explanation
M	Number of macro data channels being used
N	Number of femto data channels being used
B	Number of new session requests waiting in the queue
C	Ratio of handover regions in eNB and HeNB
M	Total number of macro data channels
N	Total number of femto data channels
B	Total number of session requests
H	Number of macro data channels reserved for HO

When the system traffic is statistically stable, the traffic intensity of the incoming handover is equal to that for ongoing handover calls, i.e. Equation (5).

$$T_o = \alpha_u T_n \tag{5}$$

The possible sessions in the handover procedure are defined as New Session and Handover Session, and the major parameters for the possible sessions are also defined as in Table 3 [10]:

Table 3
The possible handover sessions

Normalized traffic intensities of new sessions	$T_n = \frac{\lambda_n}{\mu}$

Normalized traffic intensities of handover sessions	$T_o = \frac{\lambda_o}{\mu}$
Normalized handover rates in eNodeB	$\alpha_u = \frac{\mu_u}{\mu}$
Normalized handover rates in HeNodeB	$\alpha_\omega = \frac{\mu_\omega}{\mu}$

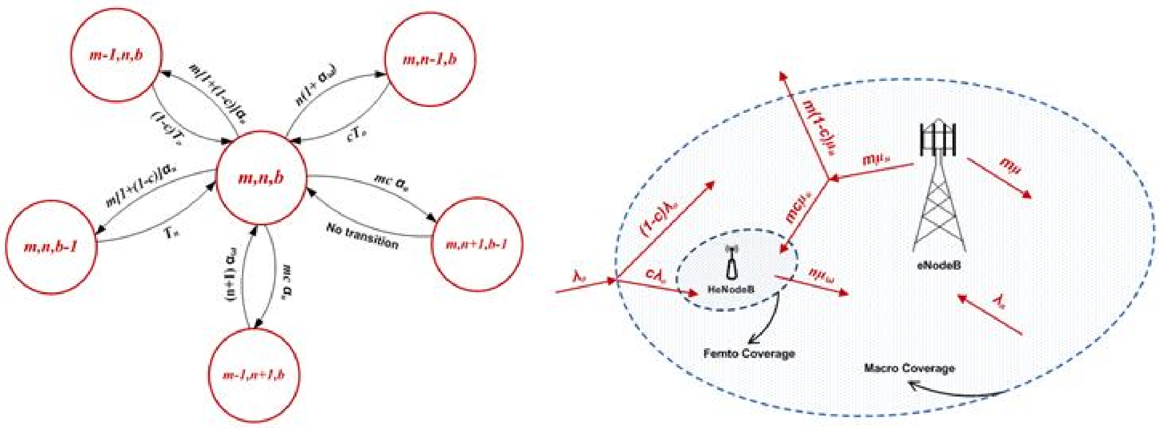
In this regard, the handover session arrival rate seen by the eNodeB is as on Equation (6).

$$\lambda_{eNB} = \begin{cases} (1-c)\lambda_o + \frac{n\alpha_\omega}{2} & if\ n < N \\ \lambda_o & if\ \ n = N \end{cases} \tag{6}$$

At the time of handover process, when the number of macro channels used is greater than the reserved macro channels for handover, i.e. $H \le m_i \le M$, the state transition from (m_i, n_i, b_i) to (m_j, n_j, b_j) are as the following states; In this case, the allocation priority is with femto, macro and handover queue (if available) respectively [10]:

a. Session completion at HeNodeB: The femto channel is released ($n_j = n_i - 1$).
b. Session completion at eNodeB: The macro channel is released ($m_j = m_i - 1$). Now if the macro channel available ($m_i - 1 < H$) then it is assigned to a new session waiting in the queue ($b_j = b_i - 1$ and $m_j = m_i$), otherwise $b_j = b_i$ and $m_j = m_i - 1$.
c. Incoming session to HeNodeB coverage area: If femto channel available ($n_i < N$), then assigned ($m_j = m_i$ and $n_j = n_i + 1$). Otherwise if macro channel available then it is assigned ($m_j = m_i + 1$ and $n_j = n_i$). Otherwise if the queue is not full then wait on the queue ($m_j = m_i$, $n_j = n_i$ and $b_j = b_i + 1$).
d. Incoming session out of the HeNodeB coverage area: If macro channel available then it is assigned ($m_j = m_i + 1$ and $n_j = n_i$). Otherwise if the queue is not full then wait on the queue ($m_j = m_i$, $n_j = n_i$ and $b_j = b_i + 1$).
e. Outgoing session from HeNodeB: The femto channel is released ($n_j = n_i - 1$). If another femto channel available then is assigned ($n_j = n_i$). Otherwise if macro channel available then ($m_j = m_i + 1$).
f. Outgoing session from eNodeB: The macro channel is released ($m_j = m_i - 1$) and then the femto channel (if available) is assigned $n_j = n_i + 1$. If any macro channel now available ($m_i - 1 < H$) then it is assigned to a new session waiting in the queue ($b_j = b_i - 1$ and $m_j = m_i$), otherwise $b_j = b_i$ and $m_j = m_i - 1$.
g. New session: Waits on the queue if the queue is not full ($b_j = b_i + 1$).

Considering the above mentioned allocation priority steps, the state transition probabilities for the above scenario, and the theoretical analysis model for handover are depicted as in Figure 10.



(a) (b)

Figure 10 (a) State transition probabilities for macro and femto (b) System model for handover analysis in LTE systems

VI. Simulation Scenarios and Results

A. Simulation Model and Considerations

To fully illustrate the impacts of the novel comprehensive handover strategy within a multi-tier LTE-A network, it is necessary to consider both the effects of the novel algorithm and advanced macro-femto combination within a unique analysis. The simulation parameters and values are revealed in Table 4 [20].

Table 4
Simulation Parameters and Characteristics

Entire Parameter	Simulation Value
Antenna gain	*15 dBi*
Max. Macro Transmission Power	*26.99 dBm*
Max. Femto Transmission Power	*10 dBm*
Terrain Model and Type	*Urban, Terrain Type A*
Propagation Model	*HATA*
Building Percentage	*31.6%*
PHY Profile	*20 MHz FDD*
FDD Uplink	*SC-FDMA*
FDD Downlink	*OFDMA*
Bandwidth	*20MHz*
Uplink Base Frequency	*1920 MHz*
Downlink Base Frequency	2110 MHz

Therefore, three different scenarios have been planned, simulated and analyzed by using of OPNET modeler network simulator. The first scenario contains an existing macro-only LTE network, in which the network users move between fixed macro base stations according to random trajectories. On the second scenario, the cooperation among macro and femto stations is simulated to support LTE users by operating the existing handover plans. As a further step towards the network performance analysis, the third scenario comprises the novel comprehensive algorithm for two-tier LTE-A network to show the improvements over the existing algorithms. The 10 LTE mobile nodes have been allocated to 4 fixed eNodeBs and 6 fixed HeNodeBs, which are managed by a central evolved packet core (EPC) entity through IP backbones and gateways.

For the packet transmission values of interference noise (Pi), background noise (Pb) and the received power (Pr), the value of signal to noise ratio (SNR) is calculated as in [3] by Equation (7).

$$SNR = 10\log_{10}\left[\frac{P_r}{P_b+P_i}\right] \qquad (7)$$

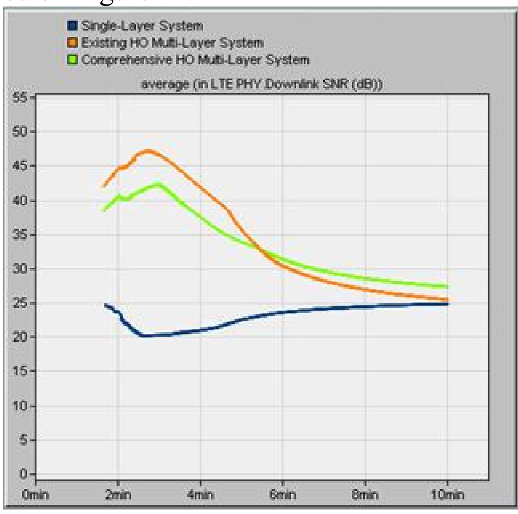
Further to the signalling values, the blocking rate of the network is also computed within the value of block error rate (BLER). This depends on the value of the received error over the total number of the blocks, and can be calculated as in Equation 8.

$$BLER = \frac{Number\ of\ Erroneous\ \text{Blocks}}{\text{Total Number of Received Blocks}} \qquad (8)$$

The insufficient range of macrocell leads to experiencing drops in quality of service for both the cases of SNR and BLER values. This has been taken into account while designing the second network layer with femtocell support to alleviate the network capacity shortage problem in new releases of LTE-A architectures.

B. Simulation Results and Analysis

The relevant function codes for process and node models for eNodeB and HeNodeB are being considered to apply for different strategies of handovers. The Access Stratum (AS) is being considered as a functional layer between LTE-A network and UE, and the performance value and number of RBs are calculated through this node model. Furthermore, the Non-Access Stratum (NAS) is applied as a functional layer between UE and core network, where the UE's regional tracking and time of residence is saved. On the other hand, the calculations that apply FoMP check are also performed on the S1 and X2 interfaces to select the most suitable interface for transmission.
Considering the explained scenarios, the transmission values for the three scenarios are depicted and compared on Figure 11.



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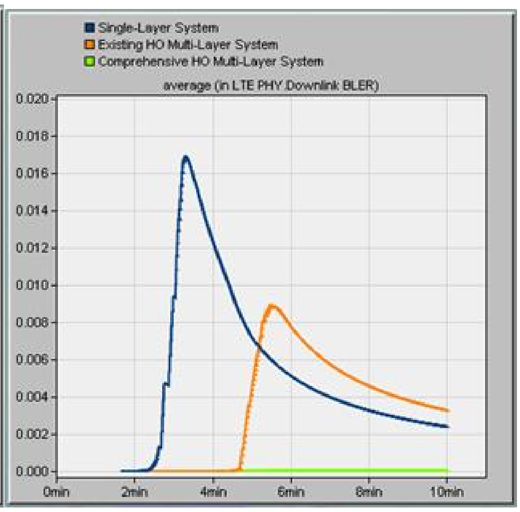

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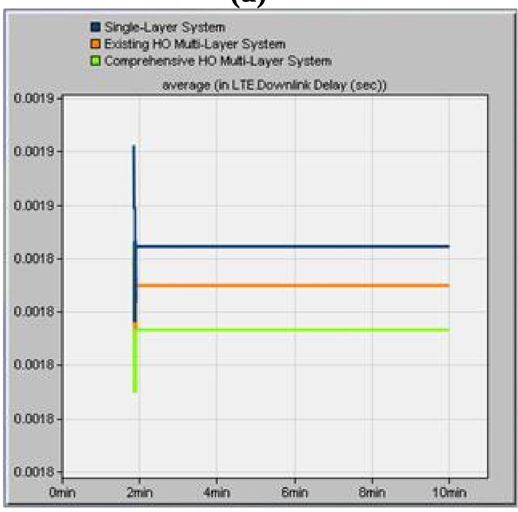

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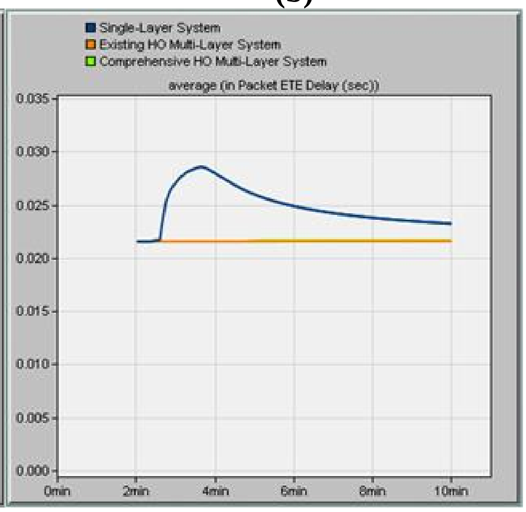


(d)

Figure 11 Comparison between simulation scenarios for (a) Downlink SNR (b) Downlink BLER (c) Downlink Delay (d) Packet End-To-End Delay

It can be observed that the values of SNR and BLER are more stable and improved by 10% and 65% for the LTE-A system enhanced by the comprehensive handover algorithm. In cases of downlink and packet end-to-end delays also, the proposed handover algorithm affects the packet delivery for the

destination mobile node in downlink, therefore the anticipated delay for the packet delivery is dropped.
The received traffic on MAC layer is also affected by the proposed comprehensive strategy. Figure 12 shows that the value of downlink MAC traffic received for the system is more satisfactory by 1.2% for the comprehensive handover algorithm.

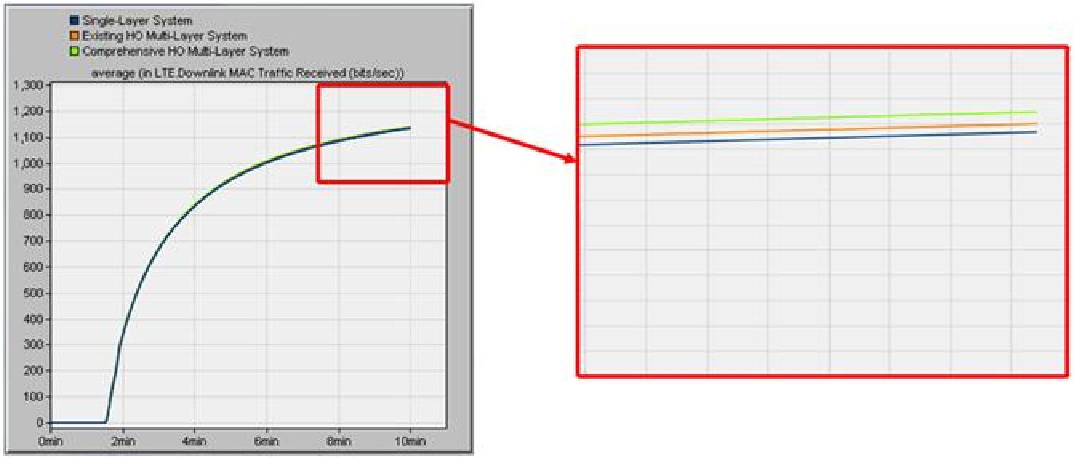
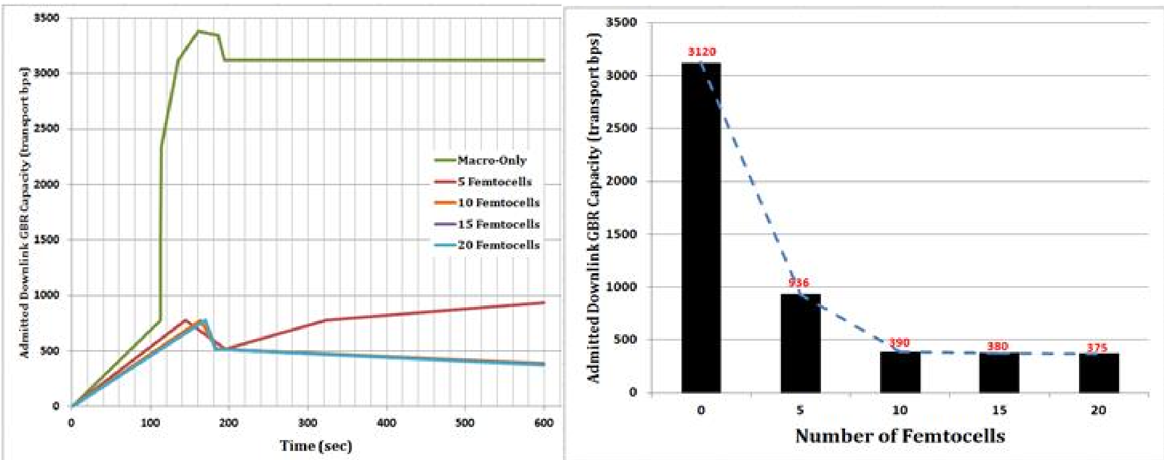


Figure 12 The MAC traffic received in downlink for different systems

This higher value for the received traffic in MAC layer is due to the mitigation of unnecessary handovers by applying the multi-check handover architecture. The LTE-A node only initiates the handover when the duration of the residence threshold is met by the mobile user while moving.
A transport block is considered as the minimum allocation size in LTE-A subframes, and the bandwidth capacity of 20 MHz in the proposed LTE-A system has 100 transport blocks per subframe (tbps). Therefore, a total of 100K transport blocks per second could be available, but only part of this number might be used for data communication [20].
Figure 13 shows the Admitted downlink GBR capacity for different number of applied HeNodeBs as transport packet per second, for the time of simulations. The simulator runs the projected scenarios for a macro-only system (no femtocell applied), 5, 10, 15 and 20 femtocells with same characteristics respectively. The results show that the scenarios with a larger number of femto stations (HeNodeBs) need a lower number of admitted DL GBR capacities, since the proposed handover algorithm switches the serving femtocells accordingly, while the mobile nodes are moving through the network.



(a) (b)

Figure 13 Admitted downlink GBR capacity against (a) Simulation time (b) Number of femtocells

VII. Conclusion and Future Work

In this paper we proposed a comprehensive algorithm for handover among macro and femto applications on LTE-A networks, by using of self-organizing instructions. Multiple checks have been designated within unique widespread algorithms to sense and decide about the best option for a target station, while avoiding the unnecessary handovers. The novel algorithm was incorporated into a multi-layer macro-femto LTE-A network and the simulation results were compared to the existing macro-only and macro-femto applications. As the results show, the physical and mac layer performances of the network, which is supported by the designated algorithm are improved, which could lead to obtain improvements in both cases of quality and capacity of the network.

Future research will focus on the other categories of handover in HetNet architectures, e.g. femto-femto handover. Also a comprehensive algorithmic application for power control is a potential research topic, while considering the interference mitigation through the multi-layer network structure.

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