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The Role of Mobility Management in Macrocell-Femtocell for LTE Network Using H.D.A

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Abstract

The population of users grows fast, that leads to an exponential increase in traffic demand for the mobile network. Offloading traffic to the macrocell is becoming the major concern of operators. Femtocells offer excellent indoor voice and data coverage. As well Femtocells can enhance the capacity and offload traffic from Macrocell networks. There are several issues that must be taken into consideration for the successful deployment of Femtocells. One of the most important issues is mobility management. Since Femtocells will be deployed densely, randomly, and by the millions, providing and supporting seamless mobility and handoff procedures is essential. LTE is an emerging wireless data communication technology to provide broadband ubiquitous Internet access. Femtocells are included in 3GPP since Release 8 to enhance the indoor network coverage and capacity. The main challenge of mobility management in hierarchical LTE structure is to guarantee efficient handover to or from/to/between Femtocells. Conventional handoff algorithms used in macrocell need some modifications to well satisfy handover management in integrated macrocell femtocell network. The handover is the most important part in the mobility management, because the handover is frequently occurred when UE is moving, hence the handover number directly affects the system performance, and network QoS. A sophisticated HO decision algorithm can improve the performance of system. Current issues and role of mobility management and handoff management are discussed. Several research works are overviewed and classified. Finally, some open and future research issues are discussed.

Keywords

Mobility Management, LTE Network, Handover Decision Algorithm

1. Introduction

Nowadays, with the instant increase in various mobile users around the world, total mobile traffics of the whole mobile world are exponentially growing [1]. Current traditional cellular network is already suffering with network capacity crisis so it is obvious that it can't cope up with this data explosion. Due to lack of resource availability, current wireless technologies are not able to use advance application in effective manner & lot of issues left unsolved in this area. Among these users, most of them highly desire high-data-rate and low delay transmissions and wireless communication systems, the primary challenge is to improve the indoor coverage, capacity raise as well as to provide users of the mobile services with high data rates in a cost effective way [2]. The key feature of the femtocell and macrocell technology are users require User Equipment (UE) [3]. The deployment cost of the femtocell is very low whereas it provides a high data rate.

Thus, the organization of femtocells at a large scale is the ultimate objective of this technology. In Fact, a well-design femtocell and macrocell-integrated network has large amounts of traffic from congested and expensive macrocell networks to femtocell networks [4]. Femtocells are consumer-deployed cellular access points, which interconnect standard user equipment (UE) to the mobile operator network via the end user's broadband access backhaul. Although femtocells typically support up to a few users, e.g., up to four users [5], they embody the functionality of a regular base station which operates in the mobile operator's licensed band. From the mobile operator perspective, the deployment of femtocells reduces the capital and operational costs, i.e., femtocells are deployed and managed by the end user, improves the licensed spectrum spatial reuse, and decongests nearby macrocell base stations. Femtocell networks are seen as a promising solution for enhanced indoor coverage and increased network capacity, as well as offloading traffic from the Macro/Micro-cells. Perhaps one of the key requirements for mass deployments and feasibility of Femtocell is mobility management. Femtocells have many special characteristics that make mobility management a crucial and challenging process. These Femtocell base stations are referred to as Femto Access Points (FAPs). They have a short-range (10-30m) and require a low power (10-100mW) [6] to provide high-bandwidth wireless communication services in a cost effective way. Femtocells incorporated with the plug and play capabilities work in mobile operator owned licensed spectrum and enable Fixed Mobile Convergence (FMC) [7] by connecting to the core network via broadband communications links (e.g., DSL).

Due to the uncoordinated nature, Femtocell poses challenge on Handover and Radio Resource Management. Long-term evolution, marketed as 4G LTE, is a standard for wireless communication of high-speed data for mobile phones and data terminals. It is based on the GSM/EDGE and UMTS/HSPA network technologies, increasing the capacity and speed using a different radio interface together with core network improvements. The network management and integration of femtocell with LTE macrocell networks is different from the existing LTE networks. Thousands of femtocells inside a macrocell area create interference problem, also due to huge number of possible target femtocell candidates for macrocell to femtocell handover, a large neighbour list and communication with many femtocells for the pre-handover procedure are needed, which may cause signalling overhead and unnecessary handovers. The architecture of LTE femtocell networks and the investigation of different scenarios in the handover procedure especially the mobility of user from macrocell to femtocell which is quite difficult due to the large number of candidate femtocells in the coverage area and the characteristics of the femtocell entity. The handover decision policy is optimized by using the benefit of the entity HeNB Policy Function to select and make decision of handover based on different constraint to make the optimal choice about the target femtocell. Developing a low complexity algorithm with a small dwell time before handing off a macrocell user to a near femtocell and vice – versa can help significantly to reduce the overall signalling overhead due to mobility.

2. MACROCELL

Macrocell is a cell in a mobile phone network that provides radio coverage served by powerful cellular base station (tower). The antennas for macrocells are mounted on ground-based masts, rooftops and other existing structures, at a height that provides a clear view over the surrounding buildings and terrain. Macrocell base stations have power outputs of typically tens of watts. A macrocell is a cell in a mobile phone network that provides radio coverage served by a high power cellular base station (tower) [8].

Generally, macrocells provide coverage larger than microcell. The antennas for macrocells are mounted on ground-based masts, rooftops and other existing structures, at a height that provides a clear view over the surrounding buildings and terrain. Macrocell base stations have power outputs of typically tens of watts. Macrocell performance can be increased by increasing the efficiency of the transreciever. The term macrocell is used to describe the widest range of cell sizes. Macrocells are found in rural areas or along highways. Over a smaller cell area, a microcell is used in a densely populated urban area. Picocells are used for areas even smaller than microcells. An example of usage would be a large office, a mall, or train station. Currently the smallest area of coverage that can be implemented with a femtocell is a home or small office. A macrocell provides the largest area of coverage within a mobile network. The antennas for macrocells can be mounted on ground-based masts, rooftops or other existing structures. They must be positioned at a height that is not obstructed by terrain or buildings. Macrocells provide radio coverage over varying distances depending on the frequency used, the number of calls made and the physical terrain. Macrocell base stations have a typical power output in tens of watts.

Figure 1. *Macrocell.*

3. FEMTOCELL

Femtocell is a wireless access point that improves cellular reception inside a home or office building. A femtocell is a miniature cell tower for homes/small businesses that extends a carrier's traditional network's range. Femtocells connect to a carrier's network over the customer's broadband internet connection and provide a strong local signal that cell phones in the building can use for any of the typical voice or data applications. Femtocells require carrier support in order to be of any use. The Samsung Ubicell 1 (Sprint Airave) is an example of a commercially available femtocell. Femtocells were originally called access point base stations [8].

The term was derived from cell and "femto", a metric prefix that stands for 10^{-15th}, or one quadrillionth, six orders of magnitude smaller than Nano. The development of femtocells is credited, in part, to the work of a skunk works team at Motorola in the UK, where they created the world's smallest full power UMTS base station.

Femtocells, short for femtocell base stations, are low-power, short-range, low-cost indoor cellular base station for better coverage and capacity, it is different than Access Point. The "femto" in femtocell means 10^{-15}. Femtocells acquired the name because they are much smaller than the standard Macrocell cellular towers. Each of Femtocells works with the major wireless telecommunications standard and connects users with cellular provider via broadband Internet links.

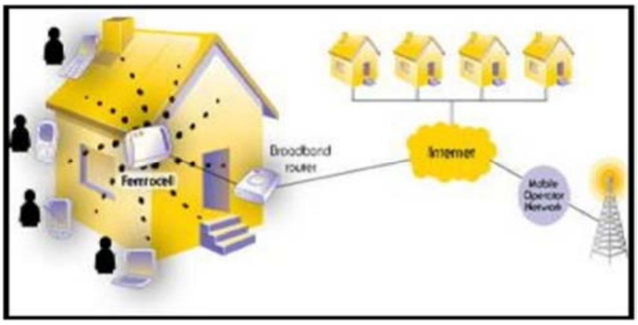

Figure 2. *Femtocell concept.*

4. LTE

LTE (Long-Term Evolution), commonly marketed as 4G LTE, is a standard for wireless communication of high-speed data for mobile phones and data terminals. It is based on the GSM/EDGE and UMTS/HSPA network technologies, increasing the capacity and speed using a different radio interface together with core network improvements.

LTE is synonymous to modern day telecommunication system; it is a Fourth Generation (4G) mobile network. In an effort to meet the ever-growing demand for wireless services; mobile networks evolved through an array of innovations, dating back to the 80s when it began with the analogue cellular network commonly known as the First Generation (1G). A decent representation for this era is the block-sized simple telephone proposed to offer basic voice communication services to users. An example of this system is the Total Access Communication System (TACS), which ran at 900MHz frequency range in the UK [9].

Second Generation (2G) emerged about 10 years later; bring about services with low bit rate such as Short Messaging Services (SMS). A prominent product of the second-generation cellular network is the GSM (Global System for Mobile communications) [9]. 2.5G came along and; HSCSD (High Speed Circuit Switch Data), GPRS (General Packet Radio Service) and EGPRS (Enhanced GPRS) or EDGE (Enhanced Data Rates for GSM evolution) were introduced in a move to advance data transmission rates from that of GSM; the rates were 57.6Kbps, 160Kbps and 384Kbps respectively [10].

The number of mobile users rose substantially over the years leading to the innovation of Third Generation or simply 3G mobile networks. 3G systems were mainly developed for data services, hence they offer up to 2Mbps. Several standardization bodies came together to form the 3GPP (Third Generation Partnership Project) that in turn, led to the advancement of WCDMA Wideband Code Division Multiple Access developed from GSM [11]. High Speed Packet Access was also integrated into 3G systems. [12] [13] 3.5G came with even better data transmission rates; an improvement on HSPA was termed HSPA+ which supports up to 11Mbps and 21Mbps for uplink and downlink respectively. Having said this; it is paramount to explore LTE network architecture with reasonable depth. Figure 3 below portrays the LTE evolution.

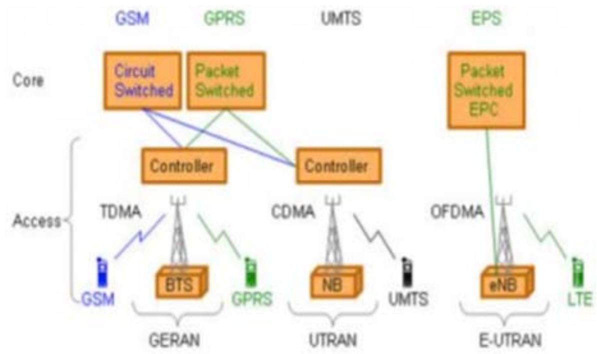

Figure 3. *LTE Evolution.*

The Long Term Evolution (LTE) is the standard name given to the mobile technology project of the 3rd Generation Partnership Project (3GPP) to meet up with the set requirements for present and future needs of mobile communications. The 3GPP LTE project started in 2004. The introduction of the LTE is aimed at enhancing the Universal Terrestrial Radio Access Network (UTRAN). Its evolvement is aimed towards achieving the fourth generation (4G) mobile technologies. The table 1 shows a progression towards the 4G technology based on the UMTS specifications evolution.

Table 1. *Evolution of UMTS specifications.*

	Release	Functional freezer	Main Radio features of the Release
1	Rel-99	March 2000	UTMS 3.84 Mcps, WCDMA FDD and TDD
2	Rel-4	March 2001	1.28 Mcps TDD, alos known TD-SCDMA
3	Rel-5	June 2002	HSDPA.
4	Rel-6	March 2005	HSUPA (E-DCH)
5	Rel-7	Dec 2007	HSPA + (64QAM DL, MIMO, 16QAM UL), LTE and SAE feasibility study EDGE Evolution
6	Rel-8	Dec 2008	LTE work item – OFDMA air interface, SAE work, new IP core network, 3G femtocells, dual carried HSDPA.
7	Rel-9	Dec 2009	Multi – standard radio (MSR), dual cell HSUPA, LTE – Advanced feasibility study, SON, LTE femtocells.
8	Rel-10	March 2011	LTE-Advanced (4G) work item. CoMP study, four HSDPA.

5. Handover Decision Algorithm

In cellular telecommunications, the term handover or handoff refers to the process of transferring an ongoing call or data session from one channel connected to the core network to another channel. In satellite communications it is the process of transferring satellite control responsibility from one earth station to another without loss or interruption of service [8].

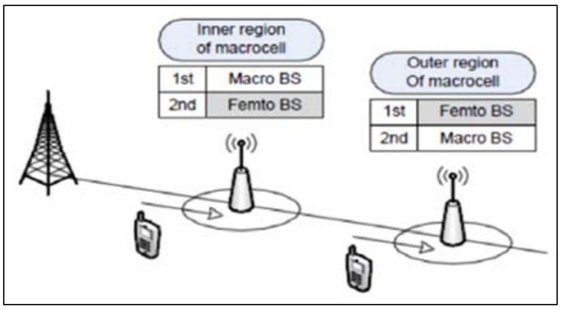

Figure 4. *Handover scenarios of MS moving from macrocell to femtocell.*

The measurement reports received from the UE are used. Some of them are forwarded to the next Admission Control step and those are the CSG ID and the UE Member Indication. The rest which include the PCIs, the CGIs and the RSRP levels are used. On one hand, the PCIs and CGIs are used to differentiate between the targets cells scanned. On the other hand, the RSRP levels are used to make the handover decision. The main objective of handover algorithm is to decide an optimal connection with respect to user or system performance, while minimizing handover latency and the number of handovers. The most commonly used algorithm is based on the comparison of RSS's and the concept of hysteresis and threshold. The threshold sets a minimum RSS from a serving BS and the hysteresis adds a margin to the RSS from the serving BS over that from a target BS. The handover decision algorithm can be utilized by a mobile station (MS) moving from a macrocell to a femtocell. Here, it is assumed that the MS has a capability to detect neighbouring femtocells. In hierarchical macro/femtocell networks, there are two interesting requirements about mobility management. First, an MS gives higher priority to a femto BS over a macro BS when the MS selects its serving BS. A reason for this requirement is not only the high utilization of femtocells but also the usage of different billing models between two types of cells. Thus, performing handover from a macrocell to a femtocell efficiently can be seen as a way of increasing user satisfaction. Second, the deployment of femtocells should not cause drastic changes on mobility management procedures used in conventional macrocell networks. It means that conventional methods, such as cell scanning and handover, can also be applied to the hierarchical macro/femto-cell networks. In the aspect of fulfilling these requirements, various handover algorithms based on received signal strength (RSS) with hysteresis and threshold have a common and critical drawback: that is, a criterion for handover from a macrocell to a femtocell is hard to be satisfied when the femto BS is installed in the centre or inner region of the macrocell. This phenomenon is caused by much lower transmit power of the femto BS compared to that of the macro BS. The typical values of the transmit power are 10 dBm for the femto BS and 46 dBm for the macro BS, respectively.

6. Mobility Management

Mobility management is concerned with many aspects, e.g. Quality of Service (QoS), power management, location management, handoff management, and admission control. Mobility Management is derived from cellular network, the network architecture in future enable to integrate various of network such as ad-hoc network, femtocell network, sensor network, internet and cellar network, to meet new type of service, as well as to efficiently manage huge number of mobile device access to serving cell. All these challenges need the support from mobility management. In other words mobility management is not solution for only one dedicated network, but also it plays a key role in much different type of wireless technology and emerging service. In addition, it needs to meet various type of mobile terminal. With the convergence of the Internet and wireless mobile communications and with the rapid growth in the number of mobile subscribers, mobility management emerges as one of the most important and challenging problems for wireless mobile communication over the Internet. Mobility management enables the serving networks to locate a mobile subscriber's point of attachment for delivering data packets (i.e. location management), and maintain a mobile subscriber's connection as it continues to change its point of attachment (i.e. handoff management).

Mobility management is the essential technology that supports roaming users with mobile terminals to enjoy their services through wireless networks when they are moving into a new service area. Mobility Management Entity (MME) handles the access network nodes, user authentication through Home Subscriber Server (HSS). It is responsible for monitoring acknowledgements, retransmissions, tracking and paging services [14]. Figure 5 shows a simple model to illustrate the basic scenario of mobile communication. The serving networks can be of any type, e.g. the Internet or intranet, mobile ad hoc networks, personal communications systems (PCS), or the mix of these networks. The mobile node can freely change its point of attachment to the networks. The main function of mobility management is then to efficiently support the seamless roaming of the mobile users and/or devices within the whole serving networks. From the view point of functionality, mobility management mainly enables communication networks to: Locate roaming terminals in order to deliver data packets, i.e. function for static scenario. And maintain connections with terminals moving into new Areas.

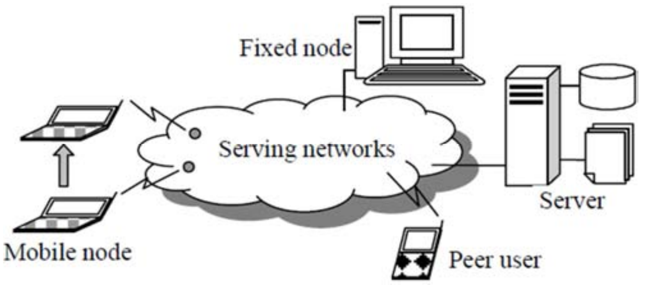

Figure 5. *Model for mobile communication.*

7. Handover Management

The handover procedure is mainly divided into three phases: handover information gathering phase, handover decision, and handover execution phase. The UE collects information about the handover candidates and during the handover decision phase, the best handover candidate is determined, after deciding to perform the actual handover, the UE initiates to connect with new FAP. Otherwise, the biggest challenge in the handover is to select the best target femtocell from so many candidates. Especially, considering the different characteristics of femtocell, like its access mode and radio resource control function, the selection and the decision of which FAP is hard to make.

The handover decision is the most important phase in the handover procedure which contains measurements and information about when and where to perform handover and obtained from one entity or more [15]. We are concerned by the handover decision method to develop the handover policies in order to optimize the selection of the optimal target femtocell in a way that multiple criteria from terminal and network sides and advanced decision is needed, this system is integrated into the HeNB PF entity.

a. Handover Information Gathering. Responsible for collecting all the contextual information, through monitoring and measurements, require to identify the need for handover and to apply handover decision policies.
b. Handover Decision. Defining all requires for the handover (policies) and how to perform it by selecting the most optimal Femtocell based on decision parameters.
c. Handover Execution. This means establishing the IP connectivity through the target access femtocell. For that, we can use fast Mobile IP functionalities as an IP mobility management solution.

Handoff management equals controlling the change of a mobile node's attachment point to a network in order to maintain connection with the moving node during active data transmission. Operations of handoff management include:

i. Handoff triggering, i.e. to initiate handoff process according to some conditions. Possible conditions may include e.g. signal strength deterioration, workload overload, bandwidth decrease or insufficiency, new better connection available, cost and quality tradeoff, flow stream characteristic, network topology change, etc. Triggering may even happen according to a user's explicit control or heuristic advice from local monitor software.
ii. Connection re-establishing, i.e. the process to generate new connection between the mobile node and the new attachment point and/or link channel. The main task of the operation relates to the discovery and assignment of new connection resource. This behavior may be based on either network-active or mobile-active procedure, depending on which is needed to find the new resource essential to the new establishment of connection.
iii. Packet routing, i.e. to change the delivering route of the succeeding data to the new connection path after the new connection has been successfully established.

8. LTE Network Architecture

The LTE is an evolution of the radio access and the non-radio access [16]; with the radio access evolving through the Enhanced UTRAN (E-UTRAN). The radio access basically is the evolution of the LTE Physical Layer, while the non-radio access grouped under the System Architecture Evolution (SAE), is the evolution of the network architecture of the LTE. The major components of the LTE System

Architectures are:

1. User Equipment (UE)
2. Radio Access Network (RAN)
3. Evolved Packet Core (EPC)

The Evolved Packet System (EPS) is comprised of the LTE Radio Access Network and Evolved Packet Core (EPC) (RAN + EPS). At the high level, the LTE network is composed of the Core Network (CN), also called the EPC while there is also the Access Network, which is referred to as E-UTRAN [16], [17], [18], [19].

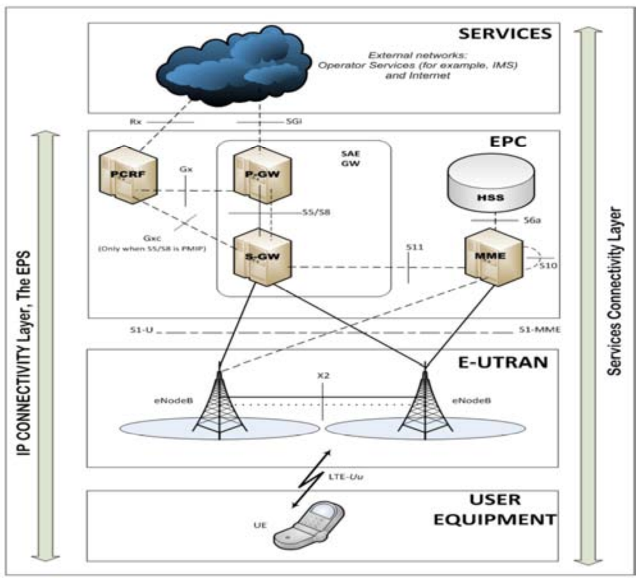

Figure 6. *Architecture for 3GPP access networks (Adapted from [20]).*

The figure 6 shows the basic overall system architecture with corresponding functional domains [20]: The four major domain divisions are - Services, the EPC, E-UTRAN and the UE as indicated while figure 7, shows the EPS network elements and the standardized interfaces. The high-level network architecture of LTE is comprised of following three main components: The User Equipment UE. The Evolved UMTS Terrestrial Radio Access Network E − UTRAN. The Evolved Packet Core EPC. The evolved packet core communicates with packet data networks in the outside world such as the internet, private corporate networks or the IP multimedia subsystem. EPS provides the user with IP connectivity to a PDN for accessing the Internet, as well as for running services such as Voice over IP (VoIP). An EPS bearer is typically associated with a QoS. Multiple bearers can be established for a user in order to provide different QoS streams or connectivity to different PDNs.

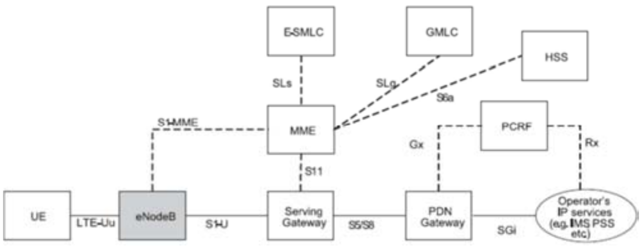

Figure 7. *The EPS showing Network Elements and Standardized Interfaces [19].*

The UE, EPC and the E-UTRAN are the integral part that formed the Internet Protocol Connectivity Layer, which is also referred to the EPS. The EPS provides the IP based connectivity services, with all services ordered at the top of the IP layer. Also, figure 8 shows a typical functional split between E-UTRAN and EPC.

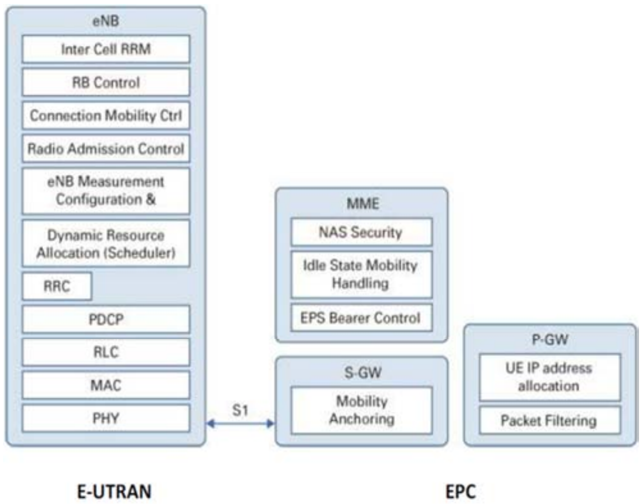

Figure 8. *Functional Split between E-UTRAN and EPC [17].*

9. Femtocell Network Architecture

Connecting femtocells to operator cellular networks requires unique architectures which can address the security needs of operators and mobile users and also support the deployment of scalable femtocell networks that can serve millions of subscribers. The femtocell network architecture is also designed to allow ordinary consumers to install femtocells with plug-and-play simplicity. Zero-touch service activation by the user is also supported by significant adaptive and self-organizing capabilities built into this architecture. Network architecture is also critical in supporting emergency calling services, which can be delivered to mobile devices inside buildings with the same accuracy and reliability as fixed-line emergency calling [21].

As shown in figure 9; Femtocell access point, security gateway & Femtocell device management system are key network elements of femtocell network architecture. Femtocell Access point is primary node of femtocell network. It performs base station & base station controller activities similar to our traditional cellular networks and connects to the operator network via the Internet. Security gateway is network node, which takes care of secure Internet connection between femtocell users and the mobile operator core network. Femtocell device management system located in operator network and takes care of provisioning, activation and operational management of femtocells using industry standards such as TR-069. It manages all online communication devices & Ensures scalability. Other than these three network elements femtocell networks uses below two entities to enable communication between femtocell & macrocell. Femtocell Convergence Server (FCS), Femtocell Network Gateway (FNG) for circuit switched calls. And Packet data serving node PDSN or xGSN for packet calls.

Femtocell network support 3 access modes:

1) Close access Mode: Access provided to only close subscriber group. The CSG manager shall be able to add, remove and view CSG membership. Inefficient use of spectrum reserved for CSG in case there are very less CSG Members.

2) Open Access Mode: Access provided to all. It's simple & no additional configuration is needed. Limiting factors are the capacity of the FAP and the capacity of the backhaul connection.

3) Hybrid Access Mode: It is combination of close & open mode. Few resources are reserved for CSG user & rest can be accessed by all.

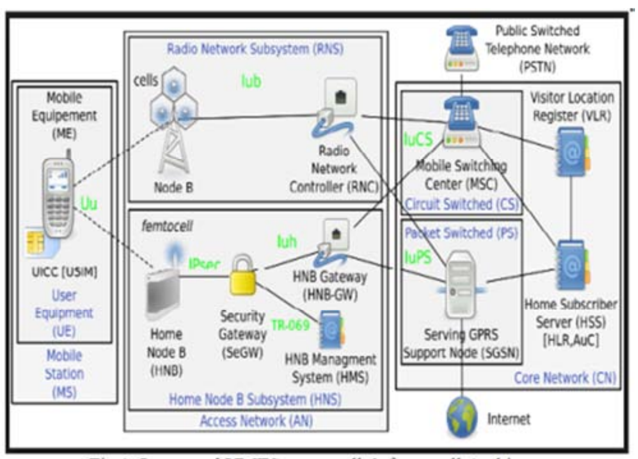

Figure 9. *Integrated UMTS macrocell & femtocell Architecture.*

The femtocell network architecture supports the following key requirements:

A. Service Parity: Femtocells support the same voice and broadband data services that mobile users are currently receiving on the macrocell network. This includes circuit-switched services such as text messaging and various voice features, such as call forwarding, caller ID, voicemail and emergency calling.
B. Call Continuity: Femtocell networks are well integrated with the macrocell network so that calls originating on either macrocell or femtocell networks can continue when the user moves into or out of femtocell coverage. Femtocell network architecture needs to include the necessary connectivity between the femtocell and macrocell networks to support such call continuity.
C. Security: Femtocells use the same over-the-air security mechanisms that are used in macrocell radio networks. But additional security capabilities need to be supported to protect against threats that originate from the Internet or through tampering with the femtocell itself. Femtocell network architecture provides network access security, and includes subscriber and femtocell authentication and authorization procedures to protect against fraud.
D. Scalability: Femtocell networks can have millions of access points. Therefore the femtocell network architecture must be scalable to grow into such large networks, while at the same time maintaining reliability and manageability.
E. The femtocell network is made up of three key fundamental components namely: the EPS (evolved packet system), HeNB (Home eNodeB) and the UE (user equipment).

The EPS consists of the EPC; which is a strictly IP-based component. In femtocell architecture, EPC signalling and data traffic are controlled by the MME and S-GW respectively. There is an intermediary mode known as the HeNB-GW (HeNB gateway) introduced between HeNBs.

There are a number of similarities and differences between eNB and HeNB. For example, one can say that they are both base stations. The line of difference is that HeNB is for short range while Macrocell is mostly for the opposite. Another differentiating factor between eNB and HeNB is with regards to number of UE access support, eNB having wider coverage naturally supports more users compared to HeNB that is mostly deployed indoors. Moreover, a fundamental feature of the HeNB is its support for Closed Subscriber Group (CSG).

10. LTE Femtocell Network Architecture and Functions

Figure 8 shows the LTE network architecture supporting femtocell and the key network elements, EPS an acronym for Evolved Packet System is consists of EPC (Evolved Packet Core), eNB (HeNB is other name for femtocell using in network protocol.) and UE (User Equipment). EPC is core network based on IP network architecture. The EPC signalling is managed by Mobility Management Entity, and data traffic is controlled by S-GW (Serving-Gateway). The eNB or HeNB and HeNB GW implements the access management, also named E-UTRAN (evolved UMTS Terrestrial Radio Access Network). The eNB and HeNB connect with MME and S-GW through S1 interface. Whereas eNBs and HeNBs interconnect with each other through X1 interface, both S1 and X2 interface are logical interfaces, they support transfer the signalling in the logical layer.

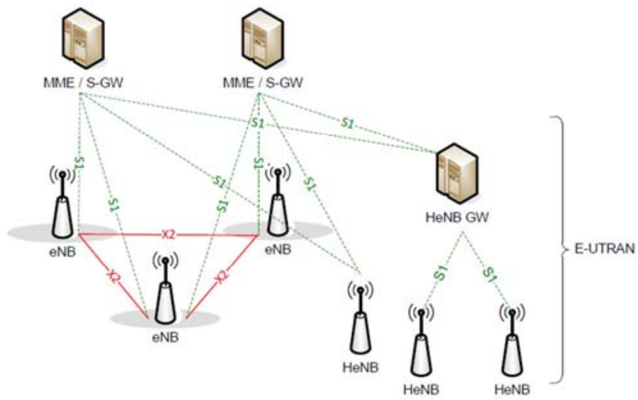

Figure 10. *Support of femtocell in LTE network architecture.*

Comparing S1, the procedure of transferring signalling for X2 is easier than S1, because the signalling is directly transferred between eNBs or HeNBs, not necessary through MME. As well as HeNB enable to be connected with S-GW and MME indirectly through HeNB-GW. As we know S1 is a logical interface interconnected the eNBs or HeNB to MME and S-GW, and separated E-UTRAN and EPC, it is consists of control plane and user plane. S1 Control plane is interface between eNB and MME in EPC. S1 user plane is the interface between eNB and UPE function in EPC. The X2 interface is between (H) eNBs. The X2 is same to S1; it also consists of two parts which are control plane and user plane. X2 control plane is interface between (H) eNBs. X2 user plane is shortcut interface between (H) eNBs. Moreover, they support the function of X2- based handover and radio resource management. In addition, the X2 is open logical interface; it provides logical indirect end-to-end connectivity between eNB and HeNB, in case of that there no exist the physical interface between them. Currently, X2-based logical interface function is more and more important in new 3GPP release, the handover between femtocells or between femtocell and macrocell is based on X2 interface. The eNB function includes Radio Resource Management, IP header compression, user packet data flow encryption, paging coordination, MME selection for UE, broadcast information coordination and measurement configuration and providing. It is a director to deal with UE accessing to network system, to archive that UE connected to core network. The network system performance is depending on eNB functions. Between LTE network and 3G network, there is large difference. First of all, LTE is partial to make the system to be hierarchical; it abandoned the Circuit Switch (CS) Service, and combined the NodeB and RNC that are used in 3G network. Additionally, the air interface is changed to OFDMA and SC-

FDMA physical wireless access technology. Mobility Management Entity is key control node that manages the mobility of UE, its function.

11. Mobility Management in Femtocell Networks

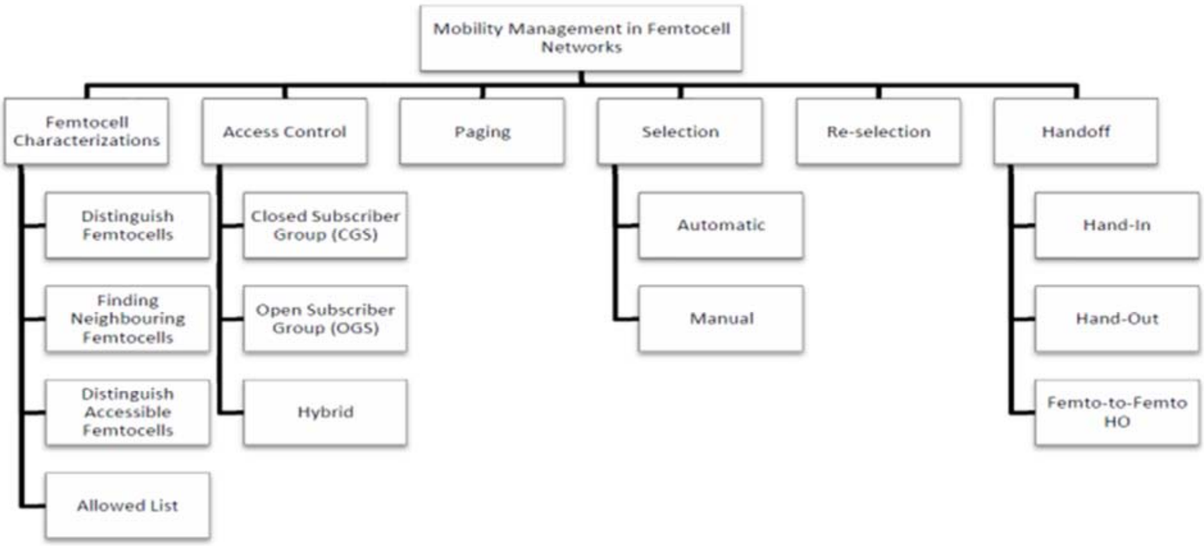

Figure 11. *Overview of mobility management functionalities in femtocell network.*

11.1. Femtocell Characterizations

Nowadays, there are more than 100 million users of Femtocell on more than 30 million access points [22]. Hence, with a large number of Femtocells randomly deployed, it is difficult to treat it as a normal Macro/Micro-cell. In addition, the network cannot afford broadcasting the Femtocell information as this will impact the overall performance of the network [23]. However, some identifiers and techniques for Femtocells are needed to reduce the impact and enhance the mobility management of Femtocell networks.

(i). Femtocells vs. Macro/ Micro-cells

With the identifiers and techniques that can distinguish Femtocells from Macro/Micro-cells the network can be divided into two tiers [24] as shown in figure 10 in this way, the signalling overhead across tier can be minimized as well as the Neighbour cell list (NCL) that the UE scans when performing a HO. The methods that have been used for such classification are listed below.

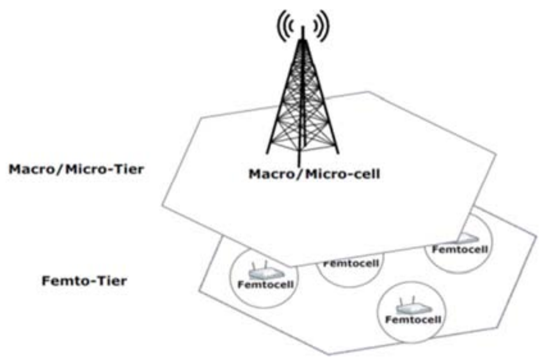

Figure 12. *Two Tier Network.*

a) Hierarchical Cell Structure (HCS): HCS can be used to distinguish between the different network cells. Each tier can be assigned different access priority (i.e. HCS_0, HCS_1).
b) Separate Femtocell PLMN ID: This technique uses a separate Public Land Mobile Network Identity (PLMN ID) for the Femtocells [25]. PLMN ID is an identifier for the operator's networks, and each operator has its own PLMN [24]. In this way, Femtocells will be assigned a different PLMN ID from Macro/Micro-cells to secure Femtocells selection and minimize impact on Macro/Micro-cells users (i.e. PLMN ID_0, PLMN ID-1) [24]. Hence, more PLMN IDs are required for operators.
c) CSG PSC/PCI: A set of Primary Scrambling Codes (PSC) (in UMTS) or Physical Cell Identifier (PCI) in LTE is reserved for identifying CSG cells of a specific frequency [25].
d) Dedicated CSG frequency list: Specifies the frequencies dedicated for UMTS CSG cells only [25].
e) CSG Indicator: Another approach is to use a CSG Indicator to define whether a Femtocell is a CSG or not [23], this is used in LTE networks.
f) CSG ID [24]: One or more CSG cells are identified by a unique numeric identifier called CSG identity (CSG ID). When the UE is not authorized to access the target Femtocell a new reject message is used. The UE will then bar the corresponding CSG ID, for a configurable duration, instead of the whole frequency (in LTE system).
g) Femtocell Name [25]: A text based name for the Femtocell sent only by CSG and hybrid cell. UE may display the Femtocell name.

(ii). Finding Neighbouring Femtocells

Depending on the above techniques, UEs are able to distinguish between Femtocells and other kinds of cells, but it is not easy to find neighbouring Femtocells due to the large numbers of FBSs. The following are techniques that have been used to find femtocells.

1) NCL: The NCL can be created by the FBS through self-configuration algorithms implemented by the vendor, and it might be updated when the FBS senses any changes of the neighbouring cells or when the FBS is turned on [24].
2) UE Autonomous Search: The objective for the autonomous search is to decide when the UE should begin searching for a Femtocell to which it can have access and whether the CSG cell is valid or not [23]. Due the limited area coverage of
3) Femtocells, the UE only starts searching for a Femtocell when the UE is in its vicinity [23]. The autonomous search function is not specified and is left to UE manufactures.
4) Manual CSG Search: This approach is specified in LTE and UMTS, where a user can find a CSG cell. On request of the user (e.g. via UE application), the UE is expected to search for available CSG IDs by scanning all frequency bands for CSG cells, and then the UE reports the CSG ID of the strongest or higher priority to higher tiers [23].

(iii). Distinguishing Accessible (CSG and Hybrid) Femtocell

By knowing whether a Femtocell is accessible or not, unnecessary signalling overhead can be avoided. The following CSG related identification parameters used to distinguish accessible Femtocell are:

i. LAI/TAI [24]: For Femtocell, the Location Area Identity (LAI)/Tracking Area Identity (TAI) of neighbours needs to be different for the purpose of user access control. The LAI of unauthorized Femtocells will be put in the UE's Universal Subscriber Identity Model (USIM) after it receives the Location Area Update (LAU) rejection from the these Femtocells.
ii. Also CSG Indicator, CSG ID, and Femtocell name are used to distinguish accessible Femtocell, whereas only CSG or Hybrid cells broadcast their CSG ID or Femtocell Name.

(iv). Handling Allowed List

The allowed list is essential in order to check whether the UE is allowed or not to access the target Femtocell. The allowed list could be in:

I. Allowed List in FBS or Femto-GW: This is a list stored locally in the FBS or Femto-GW that contains the UEs that are allowed access [24]. The operator or owner can manage the allowed list. This approach is used in UMTS.
II. Allowed List in CN: In LTE, a UE's Allowed CSG List (ACL) [23] is provided. ACL is the list of CSG IDs (FBSs) that the UE belongs to [23]. The ACL is stored with the user's subscriber information in the CN, as well as, it may keep a copy in UEs.

11.2. Access Control

Access control mechanisms play an important part in Handoff management, as well as when a user tries to camp on a Femtocell to prevent unauthorized use of that Femtocell and in mitigating cross-tier interference. Users of Femtocells in two-tier networks are classified into [26]:

1. Subscribers of a Femtocell, which are users registered in it, and they have the right to use it. Femtocell subscribers could be any UEs, for instance cell phone, laptop, etc.
2. Nonsubscribers, which are users not registered in a Femtocell.
3. Location Access Control: There are many possible locations of access control in the Femtocell network. The possible locations are [24, 23]:
4. Access Control in FBS or Femto-GW: Access control is performed in FBS or Femto-GH for Femtocell while for Macro/Micro-cell in CN. For instance in LTE,

Femto-GW shall perform access control, and FBS may optionally perform access control as well.

a. Access Control in UE: In LTE, UE can perform the basic access control in the registration procedure to enhance the mobility procedure.
b. Access Control in CN: In WiMAX and LTE, one of the CN entities (such as admission server) checks the access of the UE to the target Femtocell by the ACL after it receives information from the Femtocell.
c. Access Control Types: Femtocells support flexible access control mechanisms.

11.3. Paging

For OSG and hybrid Femtocells, the CN pages the UE in all cells that the UE is registered in [24]. For CSG Femtocells, there may be many CSG Femtocells that the UE is registered in but the UE is not allowed to camp on. So, the paging procedure needs to be optimized, in term of minimizing the amount of paging messages used to page a UE Femtocells [25]. CN and/or Femto-GW can perform the paging optimization [24]. If the paging is managed by the Femto-GW, this is left to vendor implementation [25].

11.4. Idle Mode, Cell Selection and Cell Reselection

It is desirable for the UE to switch to its Femtocell when the received signal from the Femtocell is strong enough to support service, even when the Macro/Micro-cell can still provide reliable service [27]. Hence, cell selection and reselection in Femtocell environments are more complicated than in Macro/Micro-cell networks [24]. There are few alternatives to enabling cell selection and reselection in Femtocells depending on the technology used.

- Cell Reselection

An UE in idle mode changes (reselects) the cell it is camped at as it moves across cells. Reselection requires parameters broadcast by the cell sites [27]. To increase battery life of the UE (with idle mode), the UE scans other radio channels only when the signal-to-noise ratio (SNR or S/N) of the current cell is lower than a certain threshold. In UMTS and LTE networks, this threshold is defined by parameters called S Intersearch and S Intrasearch [27]. Cell reselection may also be as an autonomous search function which is intended to find CSG/Hybrid Femtocell to the UE to camp on it [25]. The autonomous search function is not specified and is left to vendor implementations [25].

• Cell Selection

There are two modes for network selection, manual and automatic. Automatic Cell

Selection is similar to that for Macro/Micro-cells. An extra CSG ID check is performed when the target cell is CSG or Hybrid, to check whether the CSG/Hybrid cell is suitable for the UE or not [27]. This technique is used in WiMAX and LTE. On the other hand, in Manual Cell Selection, the UE is supported to select their serving CSG manually. But in the connected mode, the UE is not allowed to support manual selection [23, 24]. This technique is used in UMTS and LTE. UMTS and LTE also use the HCS in the selection of a FBS by given the Femtocell higher priority than Macro/Micro-cells [24].

11.5. Connected Mode and Handoff

When a UE in connected mode is moving with an active voice or data session, and it changes its serving cell, a process is known as Handoff (HO). There are three scenarios of the HO in Femtocell Networks: Hand-In, Hand-Out and Femto-to-Femto HO, as shown in figure 11.

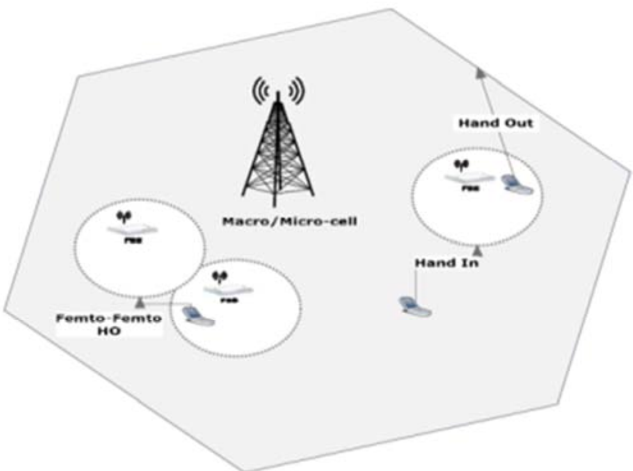

Figure 13. *HO Scenarios in Femtocell Networks.*

1. Hand-In takes place when a UE moves from a Macro/Micro-cell to a Femtocell. Hand-In is the most complex scenario since it requires the UE to select an appropriate FBS while considering neighbour cells. As well, there is no simple mechanism for the Macro/Micro-BS to determine the identity of the target FBS from the measurement reports sent by the UE.

2. Hand-Out takes place when a UE moves out of a Femtocell to a Macro/Micro-cell. Hand-Out process is supported in Femtocells almost without any changes to the existing Macro/Micro-cell network or to the UE. The handling neighbour cell is easier than Hand-In case, since the target cell is always one.

3. Femto-to-Femto HO takes place when a UE moves out of a Femtocell to another Femtocell, and requires handling long NCLs. Access control in Femtocell networks makes the HO procedures more complex than in Macro/Micro-cell networks, especially in Hand-In and Femto-to-Femto HO [24]. In addition, in Macro/Micro-cell networks, HOs are triggered when users enter the coverage area of other cells. However, given the coverage size of open/hybrid access Femtocells, this occurs more often than in the Macro/Micro-cell case. Hence, different HO management procedures are needed to allow non-subscribers to camp for longer periods at nearby Femtocells. In 3G Femtocell networks, there no support for soft HO [24]. In LTE Release 8, there is no support for Hand-In and Femto-Femto HO. However, 3GPP Release 9 supports Hand-In. 3GPP Release 10 will enable Femto-to-Femto HO [24, 27].

12. Efficient Mobility Management in LTE Femtocell Network

LTE allows the MS to belong to a list of various TAs to avoid the frequent location registration when the MS is "ping-ponging" between two TAs [36]. It however causes the potential heavy burden in the mobility management for the femtocell/macrocell network. Given all the femtocells are assigned with the same TAI but different from macrocell, the huge paging cost is accumulated because the dense femtocell deployment requires the MS searching involving hundreds to thousands of small BSs. If the femtocells are partitioned into small TAs each with the unique TAI, the MS must frequently perform TA update to keep the multiple TA associations which generates massive signalling overhead in the location registration. There are some efforts on optimizing the mobility management for LTE small cells or femtocell. Especially, [37] presents a Delay Registration (DR) algorithm to reduce the signalling overhead in the network. It postpones the location registration until a delay timer expires when MS enters the overlapped femtocell. However, the overhead is reduced at the expense of degrading the traffic offload capability. Call arrival rate for each MS must be estimated very accurately for the effective implementation. These requirements restrict its feasibility mean while causing more processing load in the CN nodes such as SGW. In Long Term Evolution (LTE), [38] the Mobility Management Entity Architecture is responsible for the mobility management function in which is connected to a group of evolved Node Base Stations. Radio coverage of an eNB is called a cell. Every cell has a unique cell identity. The cells are group into the Tracking Areas (TAs; e.g., TA 1 contains Cell 1 and Cell

2). Every Tracking Areas has a unique Tracking Area identity (TAI). The Tracking areas are further grouped into TA Lists (TALs). User Equipment (UE) stores the TAL that includes the TA where the User Equipment (UE) resides. Now, Mobility Management has four key Challenges which are listed; femtocell characterization / identification, Access Control, Network Discovery, Handover.

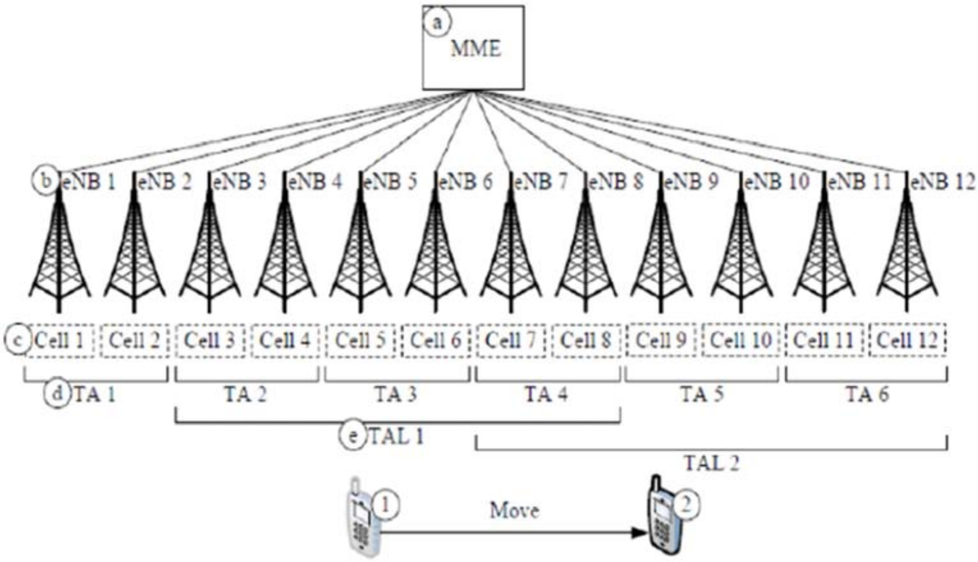

Figure 14. *Mobility Management Architecture for LTE based Networks.*

In LTE network, the handover decision between two eNodeBs are made by the eNodeBs entity itself without consulting with the MME: the source eNodeB decides to move the UE to the target eNodeB based on UE measurement report, the target eNodeB prepares radio resources before accepting the handover, after a successful handover, the target eNodeB indicates the source eNodeB to release the resources and sends a path switch message to the MME. The latter sends a User Plane Update Request to the S-GW about to which eNodeB the packets for the user shall route. The control messages are exchanged via the X2 interface between the two eNodeBs, and the downlink packet data is also forwarded from the source to the target eNodeB via the same X2 interface [39] [40].

12.1. Mobility Management Techniques

Network-based Mobility Management: In this type of mobility management protocols, the network takes care of all aspects of mobility management without requiring participation from the UE in any related mobility procedures and their signalling. This domain does not require the UE to be involved in the exchange of signalling messages between itself and the network.

Mobile-based Mobility Management: This type requires the participation of the UE in all aspects of the mobility management. However, the participation of the UE in the mobility management and associated resources and software has become a hurdle for standards and protocols.

Mobile-Assisted Mobility Management: In this type, the information and measurement from the UE are used by the network to take care of all aspects of the mobility management.

12.2. Handover Scenario in Femtocell

The handover procedure allows communication during user's movement among the network, it is critical to support the user's mobility in all current mobile systems including the femtocell network. The handover procedure in femtocell network contains three scenarios [41].

(i). Hand-in Procedure (Macrocell↔Femtocell)

Represents the handover scenario where a UE switch out from macrocell eNodeB to HeNB, this scenario is a difficult procedure and quite demanding since there are hundreds of possible targets HeNBs. In hand-in procedure, the UE needs to select the best target HeNB so the optimal handover decision policy is so critical and difficult, so we take advantage of the entity HeNB PF to select the most appropriate target HeNB according to the predefined rules.

(ii). Hand-off Procedure (Femtocell↔ Macrocell)

The handover that is performed from HeNB to macrocell eNodeB, it is not so complicated as the hand-in, because there is only one candidate and UE is no need to select the optimal target cell or to use the HeNB PF entity. That is to say that complex target cell selection mechanism is unnecessary. When the signal strength from the macrocell is higher than the one from serving HeNB, the UE will connect to it and transmit the data packets using the target macrocell eNodeB without considering so many elements as those in the hand-in decision making phase.

(iii). Inter-HeNB Procedure (Femtocell↔Femtocell)

It represents the interaction between two HeNBs, the handover from one HeNB to another HeNB in the same macrocell network. The inter-HeNB handover is similar to hand-in procedure since in this scenario, there are still hundreds of candidate target HeNBs when UE move out the coverage of its serving HeNB. So in this scenario the target cell selection mechanism is necessary an on appropriate selection for the efficient handover required. Therefore, in this situation we need to use HeNB PF to select the optimal target HeNB.

13. Mobility Management Issues

Mobility management in Femtocells should offer a seamless experience for users as they move in and out of Femtocell coverage. Since, existing cellular networks and mobile devices have been designed without awareness of Femtocells; these requirements must be met without requiring changes to existing infrastructure or to mobile devices. Dense deployments will cause serious issues on mobility management between the Macro/Micro-cells and Femtocells. The importance of mobility management in Femtocell networks is due to the following reasons:

I. Large number of FBSs that are usually overlaid with Macro/Micro-BS coverage.
II. High density of FBSs.
III. Dynamic neighbor cell lists.
IV. Variant access control mechanisms.
V. Different user preferences.
VI. Different operator policies and requirements.

The above characteristics pose the following issues:

1. Neighbour Advertisement Lists and Messages

Since large numbers of FBSs may be within the range of a single Macro/Micro-cell, a long list of neighbouring FBSs would be broadcast via neighbour advertisement messages. This leads to a waste of the wireless resources and makes the process of scanning all neighbouring Femtocells time consuming [28].

2. HOs

Current Macro/Micro-cells share the radio frequency with potentially huge numbers of Femtocells. Hence, a UE may face up continual HOs, especially when it moves around the home or enters areas where the received signal from the Macro/Micro-cell is greater than that from the Femtocell [29]. In addition, leakage of coverage to the outside of a house may occur and can lead to highly increased number of unnecessary HO of Macro/Micro-cell users, which may lead to higher call dropping probability. Femtocells also introduce specific complexities in Hand-In and Femto-to-Femto HO [30, 28, 31, and 32].

3. HO Decision Parameters

In Femtocell environments, new and flexible decision parameters will influence the HO other than existing parameters, such as serving cost, user's status and preferences, load balancing, [31, 33] etc. In other words, the serving cell and/or UE should decide to handoff to a target cell based on multiple parameters. There is a need for algorithms to optimize and adapt these and other parameters.

4. Searching for FBS in Different Access Scenarios

In order to manage the mobility procedures in both idle and connected modes, with the case of hybrid and CSG scenarios, there are two problems to be solved. The first problem is how the mobile devices will find out that the target is the CSG or not. The second problem is how to identify target CSG cell as the mobile device's own accessible FBS among many of FBS [33, 23].

5. Idle Mode Mobility Procedures

Additional energy consumption should be taken into account due to the high dense deployment of Femtocells and their continuous receiving and transmission signals [34]. The increase of the number of cells can result in a large increase in the traffic and load of the CN for idle mode mobility procedures [34, 35].

14. Mobility Management in LTE Femtocell Network issue

Currently, the majority of data traffic occurs at the indoor environments. Over 35% of mobile voice services and more than 40% of mobile data traffic occurs at home or at the office and maintained an increasing trend. Thus it can be seen that there is huge number of mobile terminal is used at indoor environments. Using femtocell is excellent way to mitigate traffic load of macrocell. But we image that so many terminal is randomly moving, accessing to cell and leaving, it makes a challenge to femtocell mobility management. How to efficiently manage the mobility of terminal is directly the aspect of performance in wireless performance.

Basically, mobility management is divided into two patterns: Location Management and Handover Management. Location Management is important part for mobile communication system. It simultaneously tracks UE; temporally report the new UE location to system, in order to let system knows the new location when system intended to establish connection with UE. Handover Management performs when UE or system discovered connection status was changed, is that, the serving cell signal strength decreased to the threshold which is not met by the connection quality. In this moment, the network system searches new cell which is fit for ongoing connection requirement for UE as target cell, remaining the ongoing connection and handover to target cell. In order to keep the seamless connection, the handover protocol is required to consider the handover failure and handover time. These two factors are crucial issues aspect the femtocell performance.

Handover procedure for LTE network can be spliced into four steps: measurement control, measurement report, HO decision, HO Execution. A more sophisticated HO decision algorithm can mitigate the negative impact of user mobility and cross-tier interference on the Quality of Experience (QoE) and Signal to Interference plus Noise Ratio (SINR) performance at the UEs. Attaining a low service interruption probability for medium to high speed users is another challenging issue for the HO decision phase.

15. Related Works

A combination of received signal strengths from a serving MBS and a target femto base station (FBS) is considered as a parameter for efficient handoff decision. A Different types of access scheme and a femtocell initiated handoff procedure with adaptive threshold were studied in When it comes to making a proper handoff decision, delay time is critical [1] [38]. It is not a latency induced by the system but a guard time to check the reliability of a BS [3]. The schemes for handover disallows the cell reselection from the macrocell to femtocell, but keeps the most suitable femtocell information available at the MS which is used to trigger the handover to femotcell for traffic offloading when call arrives. It reduces the signalling cost mean while preserving the traffic offload capability of the femtocell, but requires any modification on the existing network. The handover algorithm cost reduction with the good adaptability to the diverse MS behaviour in high mobility.

Lan, Yongsheng & Zhenrong (2009) "Mobility Management Schemes at Radio Network Layer for LTE Femtocells". Proposed solutions for HeNB HO, Introduce the HeNB gateway to control HeNB. Their first proposal used HeNB GW to restrict HeNB traffic. Their second proposal did not limit traffic nor aligned with 3GPP specs.

Kwak, Lee, Kim, Saxena & Shin (2008): "Mobility Management Survey for Home eNB Based 3GPP LTE Systems". They explained factors affecting HeNB HO. They identified RSSI as main determinant Load balancing. Lack of Automatic Neighbor Relation (ANR) Lack X2 interface in HeNB UE mobility speed.

Haijun, Wenmin, Wei, Wei, Xiangming & Chunxiao (2011), "Signaling Cost Evaluation of Handover Management Schemes in LTE-Advanced Femtocell". Proposed algorithm for HO based on mobility. HO at low mobility for better QoS. Time to stay was also considered. HO discourage at high mobility. Assumed cells had clear boundaries, considered only mobility for HO.

Old – HO increased with high mobility. More HO and less data transferred, New less HO at high mobility. No HO at very high mobility.

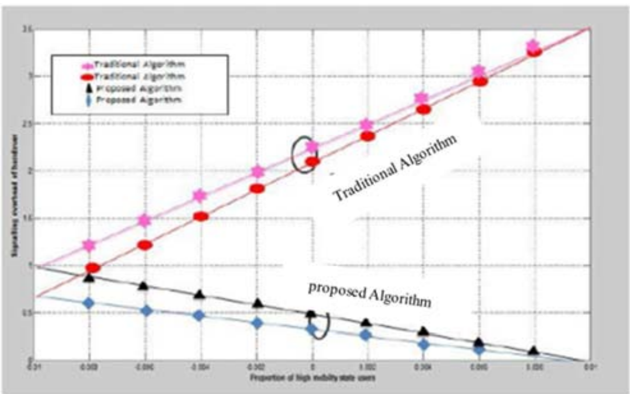

Figure 15. *Signalling overhead versus high speed user proportion (Haijun, Wenmin, Wei, Wei, Xiangming & Chunxiao, 2011).*

Future of LTE (2013), as a point of emphasis, it should be noted that femtocells can be a formidable force to reckon with at the present and in the future, if very sensitive concerns are looked into critically. The issue of privacy and confidentiality are of paramount importance in our world of technology today; and every user wants a certainty within a particular level of trust. As said earlier, recent allegations about snooping or hacking by some government agencies via the femto-cellular networks has created much of a greater concern of how secured or safe to use the femtocell. Aside from that, there has been a discussion about citizen-to-citizen (C2C) attack via the femtocells, particularly in the area of interference management, self-organization, enhanced antenna system, mobility management and so on.

In femtocell network, several research works have been published. In [39], it proposed a mobility management scheme that move the mobility anchor for user plane from the S-GW to the HeNB GW and let the HeNB make the handover decision in HeNB- HeNB handover scenario.

The author (3GPP TS 25.367 V9.3.0 (2010-03).) has introduced a call admission control optimization algorithm based on velocity and the real-timing attribute of the user's service for femtocell network. However, the algorithm involved the detection and the judgment of the real timing attribute, which is complicated and not suitable for a cost-effective implementation.

In [15] it proposed a new Autonomic Architecture with Self-organizing capabilities based on the election of a Femtocell cluster Head (FH) for each group of Femtocell APs. The FH will be responsible to dynamically adjust the network overall coverage to save FAP energy and provide better QoS to users.

More detailed works on handover in femtocell network, (J. M. Moon and D. H. Cho) proposed a handover decision algorithm that combined the values of received signal strength from a serving macrocell and a target femtocell in the consideration of large asymmetry in their transmit powers in eNB-to-HeNB handover scenario, a combination of received signal strengths from a serving MBS and a target FBS is considered as a parameter for efficient handover decision. This is a case when a handover decision is based on a combination factor and the critical weights are determined different for various situations.

In (B. Jeong, S. Shin, I. Jang, N. W. Sung, and H. Yoon), a mixture of mobility pattern and location prediction is taken as the measure to reduce the number of unnecessary handovers due to temporary femtocell visitors.

Monitoring process times at application layer by maintaining sessions with promising mobility management is detailed (N. Banerjee, K. Basu, and S. K. Das,). Other inclusions are a management server which maintains a list of correspondent to a BS relative to its neighbours. MOBIKE method is realized as a requirement for femtocell networks to support vertical handovers between legacy and at mode to give uninterrupted, delay sensitive services like VoIP (T. Chiba, S. Komorita, and H. Yokota,).

16. Discussion

Many research efforts have been made to modify and adapt the existing mobility management procedures in cellular networks to be used with Femtocells. The mobility management schemes in Femtocell networks have also been observed. We saw the description of mobility management techniques which also help in understanding the role of mobility management.

Although there are numerous proposed solutions for HO in Femtocells, most of the solutions have targeted only one or two parts of the HO procedure, such as HO preparation, HO decision parameter, HO signalling, Hand-In algorithm, etc. A few solutions have proposed a comprehensive HO procedure.

The growing demand for high-speed Internet connection has led to major technological advancements, including femtocell base stations. Femtocell base stations are small inexpensive low power base cellular base stations used for extending signals received from macrocells. The deployment of femtocell has since become a norm in modern day telecommunication industry. However, these deployments come with several challenges, including but not limited to mobility management. Handover has proved to be the most important property of mobility management for macrocell-femtocell deployments in LTE networks.

Zhang [28], Wang [30], Ulvan [31] provide schemes for the signalling flow of the HO process with different additional parameters to reduce the number of unnecessary HOs. For example, Wang [30] supports CSG and OSG scenarios in the Femto-Femto HO. The scheme uses the user speed, QoS, and load balancing as additional parameters for the HO decision. The HO latency and signalling overhead are increased due to additional gateway (Femto-GW) that is installed.

The random femtocell deployment may result in degraded SINR performance, increased outage probability, and enlarged network signalling, if the interference-agnostic strongest cell policy is employed during the HO decision phase. The key feature of femtocell deployment and a presented novel HO decision policy for reducing the UE transmit power in the macrocell – femtocell LTE network given a prescribed mean SINR target for the LTE users. This policy is fundamentally different from the strongest cell HO policy, as it takes into account the RS power transmissions and the RF interference at the LTE cell sites. The impact of using an increased HHM for mobility mitigation has also been investigated in terms of HO probability.

As we know that handover is the most important part in the mobility management, because the handover is frequently occurred when UE is moving, hence the handover number directly affects the system performance, and network QoS. A sophisticated HO decision algorithm can improve the performance of system.

Provision of a survey on the vertical mobility management process and mainly focuses on decision making mechanisms. Mobility management provides a way to retain the ongoing session of the mobile node. It is crucial to provide efficient handoff mechanism support for mobile devices. A mobility management protocol provides fast handover along with route optimization. Mobility management deals with location of the subscriber for data delivery, maintenance of the subscriber’s connection during change of location from one base station to another. Mobility management enables communication network to locate roaming terminals in order to deliver data packets, i.e. function for static scenario and maintain connections with terminals moving into new areas, i.e. function for dynamic scenario. These are some important roles of mobility management; Mobility management in Long Term Evolution (LTE) is different from that in the third generation mobile telecom networks. In LTE, the Mobility Management Entity (MME) is responsible for the mobility management function.

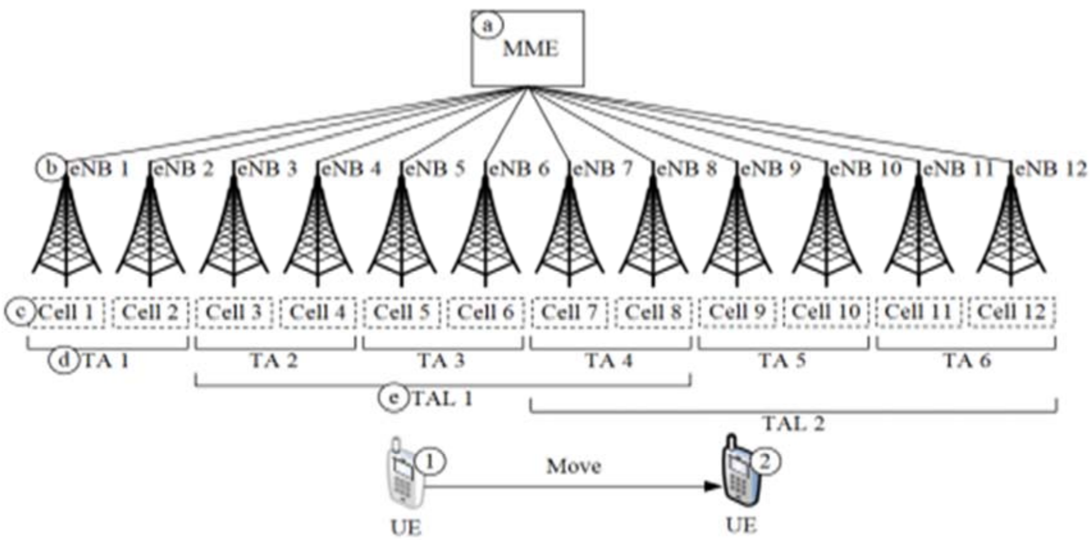

Figure 16. *LTE mobility management Architecture.*

Discussion has been made on the role of mobility management in next-generation wireless networks with the help of macrocell-femtocell using handover decision Algorithm. Issues in location registration and handoff management have been identified and several existing mechanisms have been presented.

17. Conclusion

In macrocell-femtocell, Mobility management has widely been recognized as one of the most important and challenging problems for a seamless access to wireless networks and mobile services. The impacts of mobility to networks are analysed. Two main operations of mobility management are defined as location and handoff managements and the processing stages of the two operations are introduced respectively, together with the discussions of key research issues and possible solutions. Some important issues involved in the performance evaluation of mobility management scheme are discussed.

The random femtocell deployment may result in degraded SINR performance, increased outage probability, and enlarged network signalling, if the interference-agnostic strongest cell policy is employed during the HO decision phase. A feature of femtocell deployment and presentation on a novel HO decision policy for reducing the UE transmit power in the macrocell – femtocell LTE network given a prescribed mean SINR target for the LTE users. This policy is fundamentally different from the strongest cell HO policy, as it takes into account the RS power transmissions and the RF interference at the LTE cell sites.

The impact of using an increased HHM for mobility mitigation has also been investigated in terms of HO probability.

Building efficient mobility mechanisms will play an important role for successful deployment of Femtocells and for providing seamless services. Methods and techniques that help in managing and updating the network topology are critical for efficient mobility procedures between Macro/Micro-cells and Femtocells and among Femtocells. All Macro/Micro-BSs and FBSs have to be aware if a FBS enters or leaves their coverage, hence changing the mobility conditions. For UEs to perform Handoff and cell searching in a more efficient way, the UE and/or FBS should acquire network topology.

With femtocell, it brings mobility management issue caused by the huge number of mobile devices moving. The handover is the most important part in the mobility management, because the handover is frequently occurred when UE is moving, hence the handover number directly affects the system performance, and network QoS. Then we can see that a sophisticated handover decision algorithm can improve the mobility management.

From the related works observed and discussed, we can see the importance and role of mobility management in macrocell femtocell network. Also, Issues in Handoff and other mobility management procedures in Femtocells are identified. Several research efforts have been presented and classified.

References

[1] Saketh Anuma Reddy, Hui Zhou, Donglin Hu, Prathima Agrawal “Handoff Management with A Delay Requirement in Femtocell Networks”, IEEE Journal, pp 119-123, March 2013.

[2] Haijun Zhang, Xiangming Wen, Bo Wang, Wei Zheng, Yong Sun “A Novel Handover Mechanism between Femtocell and Macrocell for LTE based Networks”, *Communication Software and Networks, 2010. ICCSN'10. Second Conference on*, pp 228-231, Feb 2010.

[3] Hui Zhou, Donglin Hu, Shiwen Mao, Prathima Agrawal, Saketh Anuma Reddy “Cell Association and Handover Management in Femtocell Networks”, *Wireless Communications and Networking Conference (WCNC), 2013 IEEE Conference*, pp 661-666, April 2013.

[4] Mostafa Zaman Chowdhury and Yeong Min Jang “Handover management in high-dense femto cellular networks”, *EURASIP Journal on Wireless Communications and Networking 2013*, pp 1-21, December 2013, 2013: 6.

[5] A. Galindo-Serrano, L. Giupponi, M. Dohler, "Cognition and Docition in OFDM A Based Femtocell Networks," 2010 IEEE Global Telecommunications Conference, pp. 1-6, Dec. 2010.

[6] T. Zahir, K. Arshad, A. Nakata, K. Moessner, “Interference Management in Femtocells,” in Common Surveys & Tutorials, vol. 15, pp. 293-311, 2013.

[7] www.en.wikipedia.org/wiki/Fixed_mobile_convergence/.

[8] www.Wikipedia.com/marocell and www.wikipedia.com/femtocell and www.wikipedia.com/handover

[9] Nicopolitidis, P., 2003. *Wireless Networks*. Chichester, West Sussex, England: John Wiley & Sons, Ltd.

[10] Webb, W., 2007. *The future* of *wireless communications*. John Wiley and Sons.

[11] 3GPP, 2003. Technical Specifications and Technical Reports for a UTRAN-- ‑ based 3GPP system. 3GPP TS 21.101.

[12] Agilent technologies, 2013. *LTE and the Evolution to 4G Wireless: Design and Measurement Challenges*. John Wiley & Sons.

[13] Rhode & Schwarz, n.d. *LTE-- ‑ Advanced (3GPP Rel. 11) Technology Introduction WHITE PAPER*. [Online] Available at: https://cdn.rohde-- ‑ schwarz.com/pws/dl_downloads/dl_application/application_notes/1ma232/1MA2 32_1E_LTE_Rel11.pdf.

[14] Saketh Anuma Reddy, Handover Management in Femtocell Networks May 4, 2014.

[15] K. Sethom Ben Reguiga F. Mhiri, R. Bouallegue., “Handoff Management in Green FEMTOCELL Network”, International Journal of Computer Applications (0975 – 8887) Volume 27– No. 4, August 2011.

[16] Hamza, J., Long Term Evolution (LTE) - A Tutorial, Network System Laboratory, Simon Fraser University, Canada, October 13, 2009. Cited at: 8.

[17] Alcatel-Lucent, Strategic White Paper, the LTE Network Architecture, a Comprehensive Tutorial, 2009. Cited at: xii, 8, 10.

[18] Hussain, S., Dynamic Radio Resource Management in 3GPP LTE, Blekinge Tekniska Hogskola, Karlskrona, Sweden, January 2009. Cited at: 8.

[19] Sesia, S. et al, LTE - The UMTS Long Term Evolution, From Theory to Practice, Second Edition, Wiley Publishers, 2011. Cited at: xii, 6, 7, 8, 10, 14, 15.

[20] Holma, H. and Toskala, A., LTE for UMTS - OFDMA and SC-FDMA Based Radio Access, Wiley Publishers, 2009. Cited at: xii, 8, 9.

[21] Woojune Kim, WHITE PAPER-Femtocell Network Architecture, May 2010.

[22] "Femtocell Access Point Fixed-Mobile Convergence for Residential, SMB, and Enterprise Markets," Research Report, ABI Research, 2010.

[23] A. Golaup, M. Mustapha, and B. Patanapongpibul, "Femtocell Access Control Strategy in UMTS and LTE," *Communications Magazine, IEEE*, vol. 47, no. 9, pp. 117–123, September 2009.

[24] Z. Jie and D. Guillaume, *Femtocells: Technologies and Deployment*. UK: Wiley, 2010.

[25] G. Horn, "3GPP Femtocells: Architecture and Protocols," Report, QUALCOMM Incorporated, September 2010 [Online]. Available.

[26] %20http://%1fwww.qualcomm.com/%1fdocuments/%1f3gpp-femtocells-architecture-andprotocols%20

[27] G. de la Roche, A. Valcarce, D. Lopez-Perez, and J. Zhang, "Access Control Mechanisms for Femtocells," *Communications Magazine, IEEE*, vol. 48, no. 1, pp. 33 –39, January 2010.

[28] P. Humblet and A. Richardson, "Femtocell Radio Technology," White Paper, Airvana, May 2010 [Online]. Available: http://www.airvana.com/technology/femtocell-radio-technology

[29] H. Zhang, X. Wen, B. Wang, W. Zheng, and Y. Sun, "A Novel Handover Mechanism Between Femtocell and Macrocell for LTE Based Networks," in *Communication Software and Networks (ICCSN), Second International Conference on*, February 2010, pp. 228–231.

[30] "Femtocells - The Gateway to the Home," White Paper, Motorola, May 2008, [Online]. Available: http://www.motorola.com/web/Business/Products/Cellular%20Networks/-

[31] Femtocell/_Document/Static%20Files/Femtocell_Gateway_to_Home_WP-%20FINAL.pdf

[32] L. Wang, Y. Zhang, and Z. Wei, "Mobility Management Schemes at Radio Network Layer for LTE Femtocells," in *Vehicular Technology Conference (VTC Spring), IEEE 69th*, April 2009, pp. 1–5.

[33] A. Ulvan, R. Bestak, and M. Ulvan, "The Study of Handover Procedure in LTE-based Femtocell Network," in *Wireless and Mobile Networking Conference (WMNC), Third Joint IFIP*, October 2010, pp. 1–6.

[34] Z. Fan and Y. Sun, "Access and Handover Management for Femtocell Systems," in *Vehicular Technology Conference (VTC Spring), 2010 IEEE 71st*, May 2010, pp. 1–5.

[35] H. Kwak, P. Lee, Y. Kim, N. Saxena, and J. Shin, "Mobility Management Survey for HomeeNB Based 3GPP LTE Systems," *Journal of Information Processing Systems*, vol. 4, no. 4, pp. 145 –152, December 2008.

[36] H. Claussen, I. Ashraf, and L. Ho, "Dynamic Idle Mode Procedures for Femtocells," *Bell Labs Technical Journal*, vol. 15, no. 2, pp. 95–116, 2010.

[37] Y. Li, A. Maeder, L. Fan, A. Nigam, and J. Chou, "Overview of Femtocell Support in Advanced WiMAX Systems," *Communications Magazine, IEEE*, vol. 49, no. 7, pp. 122 – 130, July 2011.

[38] Yifan Yu, Daqing Gu "The Cost Efficient Location Management in the LTE Picocell/Macrocell Network", *IEEE communication letter,* vol. 17, pp. 904-907, May. 2013.

[39] Huai-Lei Fu "Reducing Signaling Overhead for Femtocell/Macrocell Networks" Mobile Computing, IEEE Transact ions on, Vol. 12 pp 1587 –1597, June 2012.

[40] Het al Surt i, Ketan Goswami "Optimization Handoff in Mobility Management for the Integrated Macrocell - Femtocell LTE Network", *International Journal on Recent and Innovation Trends in Computing and Communication*, Vol. 2, pp 63-67

[41] 3GPP TS 25.467 V9.2.0 (2010-03), UTRAN architecture for 3G Home Node B (HNB); Stage 2

[42] 3GPP TR 23.839 V0.1.1 (2010-05), "Study on Support of BBF Access Interworking".

[43] L. Wang, Y. Zhang, and Z. Wei, "Mobility management schemes at radio network layer for LTE femtocells," in IEEE VTC'09, pp. 1–5.