Handoffs in Femtocell and Efficient Mobility Management in LTE Femtocell Network

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Abstract:
Femtocells, as known as "Home E-UTRAN Node B" (HeNB) is the tremendous network technology in the Long Term Evolution (LTE) network which is a small base station deployed in homes, buildings, offices or other locations that is designed to improve indoor capacity and signal coverage, as well as reduce the macrocell traffic. Integrated femtocell/macrocell networks, comprising a conventional cellular network overlaid with femtocells, offer an economically appealing way to improve coverage, quality of service, and access network capacity. The key element to successful femtocells/macrocell integration lies in its self organizing capability. Provisioning of quality of service is the main technical challenge of the femtocell/macrocell integrated networks, while the main administrative challenge is the choice of the proper evolutionary path from the existing macrocellular networks to the integrated network. This paper illustrates how Femtocell network becomes a solution for indoor capacity and coverage issues based on the three different accessing modes in femtocell networks as well as its important part in the mobility management, because the handover frequently occurred when UE is moving, hence the handover number directly affects the system performance, and network QoS.

Keywords: Femtocell, Macrocell, Mobility Management, Long term Evolution(LTE), Quality of Service(QoS), User Equipment(UE), Home e-NodeB.

1 INTRODUCTION
The wireless revolution today is having a profound impact on the way people work and live. More people all over the world are having a mobile phone than having a PC. The mobile wireless handheld devices have overtaken the wired computers as dominant internet access throughout the world. With the introduction of new and varied mobile devices like smart phones, tablets every now and then in the market, their efficient use requires a serious thought as these devices now a days are not used for voice only but data services are equally important. With the wireless revolution new wireless technologies are also taking shape [1]. The best way to increase the system capacity of a wireless link is by getting the transmitter and receiver closer to each other, which creates the dual benefits of higher-quality links and more spatial reuse. In a network with nomadic users, this inevitably involves deploying more infrastructure, typically in the form of microcells, hot spots, distributed antennas, or relays. A less expensive alternative is the recent concept of femtocells — also called home base stations — which are data access points installed by home users to get better indoor voice and data coverage [2].

1.1 MOTIVATION FOR RESEARCH IN HANDOFF AND EFFICIENT MOBILITY MANAGEMENT IN FEMTOCELL NETWORK
At present, we are entering age of mobile communication, because of mobile device function is more and more near to computer, people's habits is changed to use mobile device. Until 2014, number of mobile phones in use is more than 69 billion, in Fig. 1.1 below describes number of mobile phones growth, it has increased as much as triple times from 2005 to 2014. The smart phone share is almost occupied in the complete market. So huge number of mobile phone and many emerging application for smartphone demand LTE system more efficient mobility management. Therefore Mobility Management play a key role in LTE network, also is a challenge for the Femtocell Network [3].

At this point it is very important to note that the Femtocell network is also supported in the LTE network architecture. Currently, International Organization for Standardization such as ITU-T.IETF.3GPP consider Mobility Management to be key research plan. 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 [2]. 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 many different type of wireless technology and emerging service. in addition, it needs to meet various type of mobile terminal. As a result, it is considered as important technology to be studied.
2 FEMTOCELL

Femtocell is the emerging network technology, which is defined as a low-cost, low-power cellular base station that operates in licensed spectrum to connect conventional, unmodified mobile terminals to a mobile operator’s network. The coverage ranges of femtocells are in the tens of meters like 10 to 20 meters. They utilize broadband Digital Subscriber Line (DSL) or cable/fiber to the home (FTTH/FTTx) Internet connections for backhaul to the operator’s core network. The Femto Access Point (FAP), also known as Home Base Station (HBS) or Home Node B (HNB) in 3GPP terminology and known as A Home eNode B (HeNB) in an LTE femtocell, is a main device in femtocell network that provides radio access network (RAN) functionality [4].

2.1 FEMTOCELL ARCHITECTURE

Several FAPs are connected to a femto gateway (FGW) through a broadband ISP or another network. The FGW acts like a concentrator and also provides security gateway functionalities for the connected FAPs. The FGW communicates with the RNC through the CN (Core network). The FGW manages the traffic flows for thousands of femtocells. Traffic from different access networks comes to the FGW and is then sent to the desired destination networks [5]. Whenever an FAP is installed, the respective FGW provides the FAP’s position and its authorized user list to the macrocellular BS database (DB) server through the CN.
It provides SON (Self Organizing Network) mechanisms. The main functionalities of the SON for femtocellular networks are self-configuration, self-optimization, and self-healing. Self-configuration includes frequency allocation. Self-optimization includes transmission power optimization, neighbour cell list optimization, coverage optimization, and mobility robustness optimization. Self-healing includes automatic detection and solution of most of the failures. Neighbour FAPs as well as the macrocellular BS and the neighbour FAPs coordinate with each other. Whenever an MS desires handover in an overlaid macrocell environment, the MS detects multiple neighbour FAPs because of the dense deployment of femtocells along with the presence of macrocell coverage [6].

Figure 2.2: Device to CN Connectivity for Femtocell Deployment [5].

2.2 BENEFITS OF FEMTO CELL.
Studies on wireless usage show that more than 50% of all voice calls and more than 70% of data traffic originate from indoors. To summarize, the key arguments in favour of femtocells are the following points are given below [7].
1. Better coverage and capacity (Higher SINR due to short Tx-Rx Distance)
2. Cost benefits.
3. Reduced subscriber turnover.
4. Improved macrocell reliability (the macrocell BS can redirect its resources toward providing better reception for mobile users).

2.3 ACCESSING MODES IN FEMTOCELLS.
Femtocells being a network used for private, enterprise or service providers purpose needs to operate on different Accessing modes so as to provide the service for targeted user [7].

- **Open Access Mode:**
In Open Access Mode any mobile user trying to access the femtocell service is allowed to do so without any discrimination or extra charge similar to the macrocell. Mostly these type of femtocells are deployed by Network Service Provider to enhance their coverage area and QoS.

- **Closed Access Mode:**
In Closed Access Mode the mobile user who is registered to the Femtocell is only allowed to access the service of these Femtocell. Other users are forced to use service of macrocell even if it is of poor service. These type of Femtocell are deployed by Organizations, Offices for their use and good reception of the mobile service.

- **Hybrid Access Mode:**
It is a Combination of Open and Closed Access Modes. In this mode the preference is given to the registered user in terms of priority and charging.

3 HANDOFF PROCEDURE IN FEMTOCELL
Generally in mobile communication, when a mobile user moves from coverage area of one Base Station to the coverage area of another while engaging in active call then the transfer of call from one Base Station to the other or from one channel to other is known as Handoff. Handoff or Handover in wireless communication has an important role to play so as to keep communication between the user pair, the
user channel has to be shifted from one BS to the other without interrupting the call, i.e., when a MS moves into another cell, while the conversation is still in progress, the MSC automatically transfers the call to a new FDD channel without disturbing the conversation.

All mobile systems including the femtocell network implement a handover procedure to support the user’s mobility. The handover, in one side allows communication during user’s movement in the network. On the other side, it significantly increases signalling overhead in the network. According to [8], it most likely that the soft handover will not be implemented in femtocell due to limited frequency allocation for femtocells. In addition, due to technological challenges and system operator requirements, the initial 3GPP specification for handover in femtocell focused on one direction only that is from FAP to macrocell eNodeB [10].

Despite having some constraints, in this paper we consider all possible handover scenarios between eNodeB and FAP and between FAPs.

There are a number of scenarios for femtocell handoff/handover which are listed below:

1. Hand-in or Inbound Procedure: This is where handover occurs from the macro-cell or standard cellular network to the femtocell.
2. Hand-out or Outbound Procedure: This is where a handover occurs from the femtocell to the macro-cell or standard cellular network.
3. Femtocell to femtocell Procedure: There will be situations where handover will occur between one femtocell and another close by. This will be commonplace in offices that may have a number of femtocells to give continuous coverage within a building. These are the three ways in which femtocell handover or femtocell handoff occurs [9].

The following diagram summarizes all the above three handoff Procedures or scenarios.

**Figure 3.1: Handover Scenario in overlaid macro-femtocellular networks [8].**

1. **HAND-IN OR INBOUND HANDOFF PROCEDURE**
   This form of femtocell handover occurs when a cell-phone or user equipment needs to transfer from a macro-cell on the standard external network to a femtocell. This form of handover is one of the most common forms, but it is also quite challenging because the macrocell and the femtocell will have different backhaul routes, and efficient communication is required between the two as well as transfer of the backhaul route. To effect an inbound femtocell handover the same basic principles are implemented as for a macro to macro handover. However signaling for the handover needs to be undertaken via the backhaul route (S1 interface for LTE femtocells). When the User Equipment is in operational it will detect local cells, including femtocells (HNBs - UMTS or HeNBs -LTE). It will therefore be ready to undertake a handover when the conditions are correct.

   The femtocells will have a unique physical cell identifier, ID and they will be known to the macrocell. In this way it is possible to effect a handover more efficiently. In view of the fact that femtocell technology is being deployed with UMTS and it is part of the deployment strategy for LTE, the method for macrocells identifying femtocells within its area is well defined within Release 9 of the 3GPP standards.

2. **HAND-OUT OR OUTBOUND HANDOFF PROCEDURE**
   Outbound femtocell handover is somewhat similar to the standard macro-cell to macro-cell handover except that the direct interface between the base stations does not exist. Signaling must take place over the backhaul link to the core network for both the macrocell and the femtocell, although the femtocell routing will include the femtocell gateway.
3. **FEMTOCELL TO FEMTOCELL HANDOFF PROCEDURE**

For the femtocell to femtocell handover, the signaling is handled entirely within the femtocell gateway - HeNB-GW via the S1 interface for LTE. Femtocell handover is a key element of femtocell technology. For femtocell technology to be adopted, the femtocell handover must be able to be undertaken effectively. While there are significant challenges to implementing it in a way that operates efficiently, because of the different backhaul routes for the signaling, these issues have been addressed. To reduce the unnecessary handovers, the velocity and angle of movement of the user is obtained and hence approximate stay time of the user in femtocell is calculated [9].

4. **MOBILITY MANAGEMENT IN LTE FEMTOCELL NETWORK**

Currently, International Organization for Standardization such as ITU-T, IETF, 3GPP consider Mobility Management to be key research plan. 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 cellular 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 [11]. In other words mobility management is not solution for only one dedicated network, but also it plays a key role in many different type of wireless technology and emerging service. in addition, it needs to meet various type of mobile terminal. As a result, it is considered as important technology to be studied.

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 a increasing trend. Thus it can be seen that there are huge number of mobile terminals that are used at indoor environments. Using femtocell is an excellent way to mitigate traffic load of macrocell. But we image that so many terminals are randomly moving, accessing to cell and leaving, it makes a challenge to femtocell mobility management. How to efficiently manage the mobility of terminal will directly affect the wireless performance [13]. 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 its role when UE or system discovers that connection status has changed, such that the serving cell signal strength decreases below the threshold which does not meet 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 affect the femtocell performance [12].

Mobility Management Entity is key control node that manage the mobility of UE, its function is summarized in Fig 3.1 Its function changes with the developing of LTE/SAE, and it is described in this paper in brief as follows:

1. **Tracking Management**

Tracking Management is to manage Tracking Area. Tracking Area is designed for UE location management, its function is similar to Location Area (LA) and Routing Area (RA) in 3G network system.

2. **Mobility Management for Idle UE Accessing**

Mobility Management is used for Idle UE Accessing. The idle status means the status of UE is idle in the ECM(EPS Connectivity Management).
3. **Mobility Management for Connected UE Accessing**

The connected status means the status of UE is connected in the ECM (EPS Connectivity Management). The status feature is as follows:

i. MME knows UE location that is within accuracy of serving eNode ID level.

ii. This status of UE mobility management is controlled by handover.

4. **Mobility Management for UE between 3GPP networks**

Indicates mobility management between UMTS/3GPP and LTE. Between 3GPP network systems, the handover is always necessary to reserve resource for target eNodeB. The Serving-GW is also key part of core network, its function mainly is to routing and transmit the packet data [11].

5. **CONCLUSION**

In this paper, the femtocell handoff/handover procedure and concept was first introduced and over viewed. The handoff techniques were evaluated based on the RSS and UE velocity. Also the LTE network was introduced based on femtocell network and how efficient mobility management plays a very vital role in this network. LTE network system proposed the femtocell to offload the macrocell traffic, solve network edge cover problem. The handover is the most important part in the mobility management, because the handover frequently occurred when UE is moving, hence the handover number directly affects the system performance, and network QoS.

**REFERENCES**


