Survey of Handover Schemes in femtocellular Networks

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***Abstract*-The Deployment of Femtocell is the emerging solution for the bandwidth limitation and coverage issues in conventional mobile network system (macrocell). The femtocell also helps to offload traffic from macrocell. But at the same time the deployment of femtocells in the macrocellular network has increased the complexity and has lead to frequent and unnecessary handovers in the femto-macro network. Various handover strategies have been proposed based on different parameters. In this paper a study of the parameters used to perform handover has been done and a comparison of various handover schemes based on those parameters has been presented.**

***Index Terms*- Femtocell, Handover, Macrocell, Received Signal Strength.**

I. Introduction

A tremendous growth is seen in the past few years in the fields of wireless networks and telecommunications. Over four billion people are using the mobile phones in the today's world , and these numbers are increasing continuously. Cellular phones, However, are continuously facing issues such as poor signal strength and call quality when used indoors[1]. In the modern age, Due to the increasing demand for higher data rates it seems impossible to cope up with the increasing demand using the conventional macrocell networks. An efficient and viable solution to the problem has been found in femtocells[2]. 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. 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 . A main device in femtocell network that is the Femto Access Point (FAP), also known as Home Base Station (HBS) or Home Node B (HNB) in 3GPP LTE terminology, provides radio access network (RAN) functionality [3]. the availability of hundreds of FAPs in a particular area most likely increases the technological challenges in handover procedure. Another challenge is the mitigation the unnecessary handover since large number of FAPs can trigger the very frequent handovers even before the current initiated handover procedure is completed [4]. A discussion about handovers is done in the later part of the paper.

A. Operation of the femtocell

As mentioned earlier, a broadband internet connection is must for Connecting to a femtocell. The femtocell encrypts all voice calls and data sent or received by the mobile phone. This improves security such that an external user can not break into a user's home network. The femtocell appears to a standard 3G cellular phone as another cellsite or macrocell, hence communicating with it seems as it is communicating with a macrocell, when the mobile phone is used outdoors. Battery life of femtocells is high, since they operate at very low radio power levels. Also, call quality is excellent as the distance between the femtocell and the mobile handset is short.

The mobile operator's telephone switch and data switch communicate with the femtocell gateway in the same way as for other mobile calls. Therefore, all services operate in exactly the same way and appear the same to the end user such as phone numbers, call diversion, voicemail etc. The connection between the femtocell and the femtocell gateway is encrypted using IPSec, which prevents interception.

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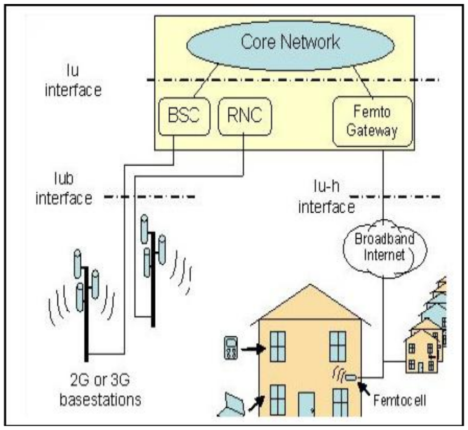

Figure 1. Femtocell deployment [5]

Authentication is also done when the femtocell is installed for the first time in order to ensure that the access point is a valid one. The complete workings of a mobile phone basestation are present Inside the femtocell . Some Additional functions , such as RNC (Radio Network Controller) processing, are also included which normally reside at the mobile switching centre. Some femtocells also include core network element so that data sessions can be managed locally without needing to flow back through the operator's switching centres. The extra capabilities of a femtocell demand it to be self-installing and self-configuring. Because of considerable extra software which scans the environment to determine the available frequencies, power level and/or scrambling codes complexity further get increased[1].

II. Literature Review

A. Femtocell integration into the UMTS architecture

UMTS is a third generation (3G) mobile communications technology which is also being developed into 4G. UMTS is sometimes referred as 3GSM, emphasizing the close relationship with GSM and differentiating it from competing technologies. The UMTS architecture is composed of three major domains: User Equipment, UTRAN and the Core Network [1].

a. User equipment (UE)

User equipment (UE) is any device used directly by an end-user to communicate. It can be a hand-held telephone, a laptop computer equipped with a mobile broadband adapter, or any other device. User equipment domain includes User Subscriber Identity Module (USIM) and mobile equipment domain. Functions such as encryption and user authentication are performed by Subscriber Identity Module(SIM).
UE handles the following tasks towards the core network:

- Call control
- Session management
- Identity management
- Mobility management

b. UTRAN

The UTRAN allows connectivity between the UE (user equipment) and the core network. This communications network, commonly referred to as 3G , can carry many traffic types from real-time Circuit Switched to IP based Packet Switched.The UTRAN is connected to the user equipment via the Uu interface and to the core network via the Iu interface. Each RNS is controlled by a radio network controller (RNC). The functions of the UTRAN include

- congestion control
- encryption and decryption
- code allocation
- handover control
- management

c. Core Network (CN)

The core network performs functions for inter-system handover and gateways to other networks (fixed and wireless). It also performs location management if there is no dedicated connection between UE and UTRAN. The core network is a combination of circuit-switching and packet switching elements. The circuit-switched elements include GSM components such as mobile services switching center (MSC), gateway MSC (GMSC) and Visitor Location Register (VLR). The packet-switched elements include GPRS components such as gateway GPRS support node (GGSN) and serving GPRS support node (SGSN) as shown in figure 2 below.
UMTS infrastructure enables GSM operators, to switch over easily to UMTS. This saves money and resources because of reuse of components. However, the standard UMTS architecture cannot sustain the addition of a femtocell. few modifications are required to the standard UMTS architecture in order to accommodate the integration of a femtocell such

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as the 3G Home NodeB (HNB), the 3G Home NodeB Gateway (HNB GW), Security Gateway (SeGW) and the 3G Home NodeB Management System (HMS).

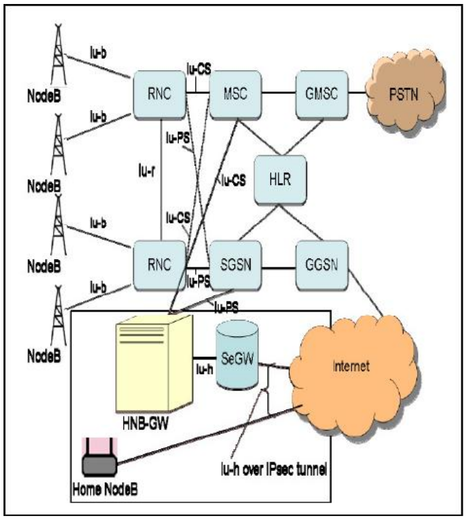

Figure 2. Femtocell in UMTS architecture [6]

- *Home NodeB*

The 3G Home NodeB (HNB) is a device that serves as a femtocell and is installed in the user's premises. Although many of the functions of a Node B is performed by femtocell, but it is optimized for deployment in the indoor premises and small coverage public hotspots. Although The concept of femtocell was initially for residential environment. However, it has evolved to include other usages such as enterprise and public hotspots. HNBs incorporate the capabilities of a standard Node B as well as the radio resource management functions of a standard Radio Network Controller RNC.

- *Home NodeB Gateway*

The Home NodeB Gateway (HNB-GW) is the device used to connect the HNBs to the UMTS network. HNB-GW is connected to the CN using the standard Iu interface and the network sees it as a standard RNC. The HNB Gateway which is installed within an operator's network aggregates traffic from a large number of HNBs back into an existing core service network through the standard Iu-cs and Iu-ps interfaces.

- *Security Gateway*

SeGW acts as a firewall between the operator's core network elements and the public internet.
The Security Gateway, installed in an operator's network, establishes IPsec tunnels with HNBs. Delivering all voice, messaging and packet data services between HNB and the core network is the responsibility of IPsec tunnels. The SeGW forwards traffic to HNB-GW.

- *Home NodeB Management System*

The management system sends the configuration data to the HNB and helps the HNB in HNB-GW and SeGW discovery. It can also initiate HNB software updates and perform HNB location verification.

B. Handover scenarios

a. Hand-in

In hand-in handover scenario the UE moves from macrocell to the femtocell coverage area.Since the UE has to select the best possible FAP out of the large number of target femtocell access point so this scenario is complex compared to hand-out[7].

b. Hand-out

Handover scenario in which a handover is performed when a UE moves from FAP to the macrocell is known as hand-out. The hand-out scenario is simpler as compared to the hand-in and inter-FAP handover scenarios because there is not much complexity in the selection or identification of the target cell as there is only one macrocell for the UE to handover to. The handover is performed when the received signal strength indicator (RSSI) from eNodeB is greater than that from FAP by a certain threshold[7].

c. Inter-femto handover

The inter-FAP handover procedure is similar to the hand-in, since there are again plenty of possible targets FAPs and the user equipment has to select the best possible femtocell for handover.

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III. Comparison of various Handover Schemes

In this section various research papers have been studied and a comparison is being made on the basis of number of parameters considered and the various results achieved but before that a brief overview of the papers is being given.

In [4] the handover procedure in femtocell is investigated. The reactive and proactive handover strategy is also proposed to mitigate the frequent and unnecessary handover.

The results obtained shows that the reactive handover is the potential mechanism to mitigate unnecessary handover. In [8] a handover algorithm is proposed based on Received Signal Strength and the speed of User equipment. In [9] an algorithm is proposed to maximize network capacity while achieving fairness among users.

Further a handover algorithm is developed to reduce the number of unnecessary handover using the Bayesian estimation. In [10] a Call Admission Control(CAC) is proposed to reduce the unnecessary handover in Hybrid access mode. In [2] the handover procedure in LTE based femtocells is discussed which is one of the major issues as the number of femtocells increases in the urban environment. Also the concept of proactive and reactive handovers is discussed and a comparison is carried out between the two simulations. An optimization algorithm is also proposed to prevent too frequent handovers and to minimize the probability of dropped calls. Simulations for the macro-femto and inter-femto handovers have been performed and the comparison is done between the conventional handover procedure and the proposed algorithm. In [11] the performance of handover strategy is analysed in femtocell network under Hybrid access mode to minimize the unnecessary handover. In [7] the reactive handover decision policy based on the prediction of user movement and the prediction of target FAP is proposed as a way to eliminate frequent and unnecessary handover. In [12] a handover mechanism is proposed where HeNB PF makes the optimal decisions based on the user type, access mode of HeNB and the current load to select the target femtocell. In [13] the architecture of LTE femtocell network is presented and also investigates the different scenarios in handover and also the probability of handover from macrocell to femtocell is being discussed. In [14] a detailed study of mobility management schemes for small and medium scale femtocell network deployment is done and also the CAC scheme to minimize the unnecessary handover are proposed. The table given below presents the different papers reviwed and the results achieved by them.

Table: Comparison of handover schemes

Handover Strategy	**Parameters**	**Results**
1. Handover Scenario and procedure in LTE based Femtocell networks [4].	Velocity of UE, Real and non real time traffic.	1.Reduction in no.of handover.
2. Handover adaptations for load balancing scheme in macrocell/ femtocell LTE n/w[8]	Received Signal Strength (RSS), Speed of User equipment.	1.Reduction in no. of handover and 2. reduction in No. of dropcalls.
3. Cell association And handover management in femtocell network[9].	Signal to interference ratio(SINR), RSSI	1.Decrease in no. of handovers 2.Increase in network capacity and 3. Increase in fairness
4. Handover in UMTS networks with hybrid access femtocells [10].	Pre-registration of user, RSSI, signal to interference level, BW.	1.Decrease in no. of handover and 2.Decrease in Unnecessary handover probability
5.Handover optimization in femtocell networks[2].	Current cell, MS velocity.	1.Decrease in no. of handover and 2.Decrease in Call drop probability.
6. Performance analysis of handover strategy in femtocell network[11].	Velocity of user, Received Signal level, Bandwidth, Registration of user.	1.Decrease in no. of handover and 2.Reduced unnecessary handover.

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7. Handover procedure and decision strategy in LTE based femtocell network[7].	RSSI, velocity of UE and traffic i.e. whether real time or non-real time.	1.Decrease in no. of handover and 2.Decrease in Handover latency and 3.Reduced Link Establishment delay.
8. Handover control for WCDMA femtocell networks[14].	RSSI, Velocity of user, CI for femtocell and macrocell and bandwidth.	1.Decrease in no. of handover and 2.Unnecessary Handover probability.

IV. Conclusion

In the last section various handover scenarios have been studied and it is observed that two handover scenarios i.e scenario '3' and '7' have achieved the maximum number of results in the terms of decreased handover, increased network capacity and good fairness index. In the handover scenario '7' Though it has been proven that the performance of reactive handover is better, the further study is still needed when this algorithm is integrated with the RF and traffic criteria that have been assigned as the handover initiation policy by the 3GPP standard. From the handover scenarios studied above it has been observed that two parameters i.e. RSSI and user equipment velocity are very important to reduce the number of unnecessary handovers and to provide the improved quality of service to the user. Further improvements can be made by combining these parameters with other parameters.

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