Handover Procedure between Macrocell and Femtocell for Long Term Evolution (LTE) Based Network

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Abstract - Long Term Evolution (LTE) is a new technology which is moving forward from the cellular 3G services. LTE is expected to reduce delays, increased user data rates, increased cell-edge-bit-rate and smoothen mobility with deployed Home eNodeB (HeNB). Femtocell which is also known as home base station is a small cellular base station. It is design to improve coverage and the capacity of the mobile network. However, because of huge number of femtocells deployment randomly in a macrocell area, this scenario can cause unnecessary handover. Therefore, an effective solution of these problems is needed to improve the performance of femtocell network. This paper proposed a handover procedure between macrocell and femtocell which it is divided into two cases. First is hand-out handover and second is hand-in handover for Closed Subscriber Group (CSG) user. Three parameters are considered in this paper which is velocity, Receive Signal Strength (RSS) and bandwidth. The results show that as the number of user increases, the number of handover is incrementing for both low and high speed. Second finding shows that this proposed procedure is able to reduce the number of unnecessary handover. This can be proven with the result which shows numbers of dropped call are decreasing when the user moved to high speed. Another result shows that by incrementing the number of femtocell in the macrocell, it will increase the number of handover.

Keywords - Handover, Long Term Evolution (LTE), Femtocell, Macrocell, Closed Subscriber Group (CSG).

I. INTRODUCTION

Mobile communication system is now change rapidly from 1st Generation in 1980 and now moving to the 4th Generation. The rapidly change of technology have increased the demand for high data rate in wireless communication. Therefore, today wireless communication system face new challenges to support the broadband data access. According to a survey in [3], about ninety percent of the services occur indoor. Therefore, mobile operators are search for licensed indoor coverage solutions to increase the capacity and improve the coverage of personal communication systems [3].

Femtocell is the best method to extend the mobile network coverage and increase the system capacity. Femtocell is also known as Home eNodeB (HeNB). It is a small cellular base station which is design to use in subscriber's home, small enterprise or outdoor areas as shown in Figure 1. It generates a personal mobile phones signal in home. Besides, femtocell connects the operator's network by using available broadband connection such as cable or Digital Subscriber Line (DSL) [2]. Femtocell has several characteristics which is different with macrocell. It has small communication range, low power, low cost and other characteristics. Femtocell technology gives benefits to the users and the system operators. For users, it provide good signal which will increase the transmission reliability. It is also increase the capacity. Besides it will reduce the power wasting and the electrical interference by offered the energy saving features. It will also reduce the calling cost at home. While for system operators, it will help them save the construction cost of the installation additional base station at macrocell and reduce the load of macrocell [3].

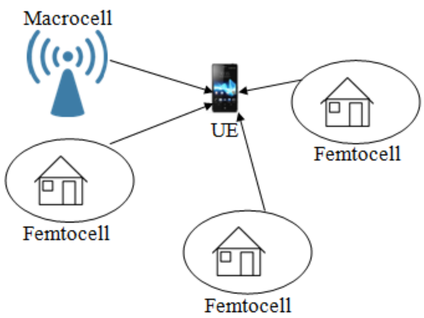

Figure 1. Concept of femtocell

The network management between femtocell and LTE macrocell networks is different from LTE networks. Huge number of femtocells within macrocell area will create pre-handover and unnecessary handover. It is because a large neighbour list and communication with many femtocells are needed. Therefore, in order to have seamless mobility handover, a proper handover procedure is needed. In this paper, we focus on two types of handover. First is hand-out handover for open access mode and second is hand-in handover for closed access mode which only consider CSG user.

The rest of this paper is organized as follows. Section II explained about the related works of femtocell networks. Section III discussed about handover scenario and the handover flows that proposed in this paper. In Section IV, the result based on the proposed handover procedure is discussed. We conclude our work in Section V.

II. RELATED WORKS

A. LTE-Based Network Architecture of Femtocell

The Evolved UMTS Terrestrial Radio Access Network (E-UTRAN) HeNB architecture which discussed by LTE femtocell standards has not yet finalized. Figure 2 shows the overall of the LTE system architecture which involve deployment of femtocell in the E-UTRAN core network [4, 5].

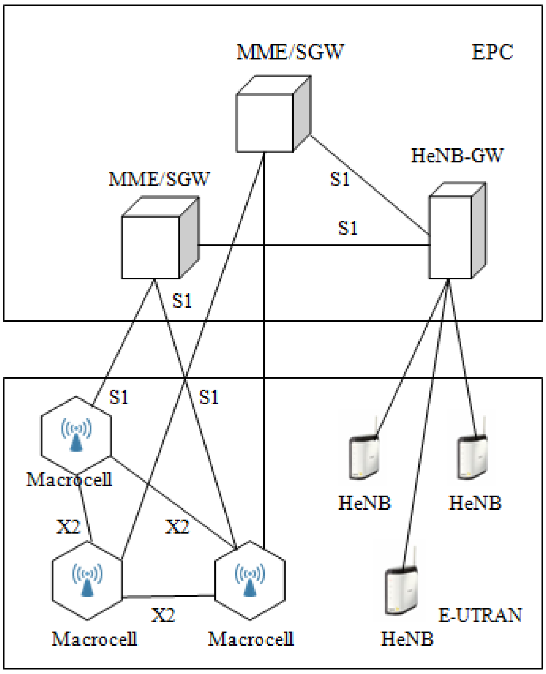

Figure 2. The overall LTE system architecture

All of the elements in Figure 2 have their own functions. Security Gateway (SeGW) is used to terminates the secure tunnelling for TR-069. It is also provides the femtocell access with access to the HeNB GW. 3GPP specified two standard interfaces which are X2 and S1 interfaces for the Evolved Packet System. X2 interface provides ability to support radio interface mobility. It is also support the exchange of information between macrocells while S1 interface support the relations between MME/SeGW and also eNodeB [3,5].

HeNB GW is function to terminate S1 from the femtocell. Besides, it appears as an RNC to the existing core network by using S1 interface. HeNB GW will support the femtocell registration and the UE registration over S1. For HeNB, it is used as Customer Premise Equipment and provides RAN connectivity by using S1 interface. It is also supports HeNB and UE registration over S1. Mobility Management Entity (MME) which is the key control node for the LTE access network is responsible to choose the serving gateway for UE [4].

B. Basic Concepts of Femtocell

Femtocell is defined as a low-power wireless access points. It is function to connect standard mobile devices to a mobile operator's network by using DSL or cable broadband connections. Femtocell is a very small base station which is located in the customer's premises. It provides high quality and high transmission of wireless communication services which is to balance the loading of macrocell. Femtocell has several characteristics such as it has small communication range, low power and low cost. Besides, it can improve the network capacity by allow the service providers to extend the service coverage indoors which in the condition where access could be limited or unavailable. Figure 3 shows the basic structure of femtocell access as deployed in LTE network [3,6].

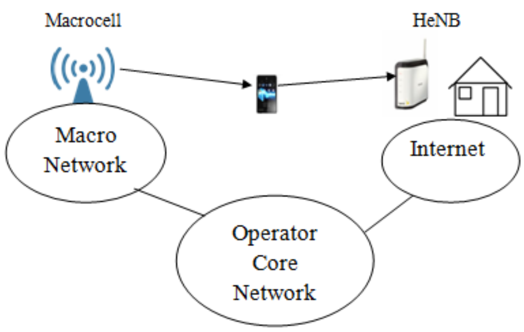

Figure 3. The basic structure of femtocell access

C. Access Control of Femtocell

In femtocell, CSG is proposed to identify subscribers of an operator whose allowed to access one or more femtocells of E-UTRAN which have limited access. It is important for the femtocell to control which UE can access to it because there may be some issues where they are sharing the backhaul link [4,6].

There are three types of access control models in femtocell which are closed access mode, open access mode and hybrid access mode [3]. For closed access mode, any UE which is not in the CSG group is not allowed to access to the femtocell. However, the system operator will provide the ability for differential charging for the UE. Second is open access mode which it has no access limits for the users. Any UE can access the femtocell when it receives higher signal level from any femtocell than that from any macrocell as long as there is extra bandwidth. For hybrid access mode, it is similar with closed access mode but it has some restrictions for the user of non-CSG. Figure 4 shows the access control management for femtocell.

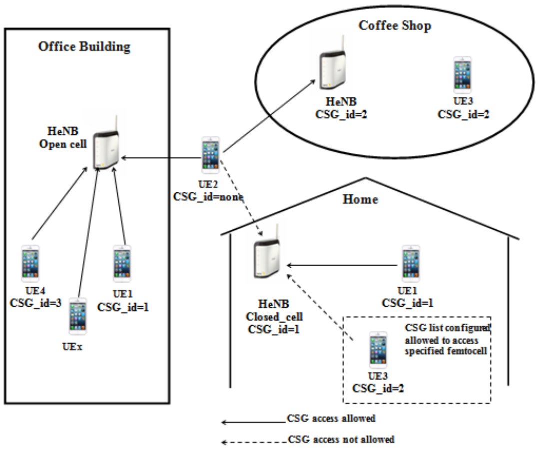

Figure 4. Access control management

III. HANDOVER STRATEGY IN OPEN AND CLOSED ACCESS MODE

A. Handover Scenario

Handover is a process when a mobile phone switches between different call sites during a phone call. It is transferred from one channel to another channel in a cellular network [1]. A proper handover procedure is important so that handover between macrocell and femtocell will operate smoothly. There are three types of handover cases in femtocell network. First case is hand-out handover. This case represents a handover from femtocell to macrocell. Second is hand-in handover which is from macrocell to femtocell. For hand-in handover, it is divided into two sub cases which are hand-in for CSG user and hand-in for non-CSG user. Third is inter-handover which is the handover occurred between femtocells. In this paper, we focus on hand-out handover and hand-in handover for CSG user only. Figure 5 describe three cases of handover between macrocell and femtocell.

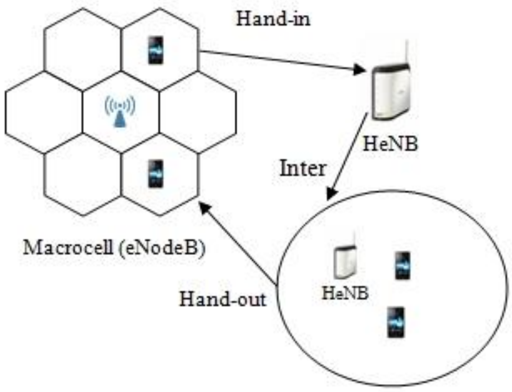

Figure 5. Handover scenario

B. Proposed Handover Procedure

To reduce unnecessary handover and to make sure that the handover process will run smoothly, an effective handover procedure is needed. Therefore, in this paper we proposed a handover procedure between macrocell and femtocell under the closed access mode and open access mode as shown in Figure 6. The open access mode is referring to hand-out handover which is handover from femtocell to macrocell. The closed access mode is referring to hand-in handover for CSG user only which is handover from macrocell to femtocell. No CSG user is needed for hand-out handover. Handover for open access mode is more complex compared to closed access mode due to regardless of CSG and non-CSG user. The handover strategy in this paper considers with Received Signal Strength (RSS) for both macrocell and femtocell, velocity (V) of mobile station and available bandwidth. We design two different velocity level which are V1=25kmph while V2=15kmph. V1 should be greater than V2 based on the 3GPP standard [3].

First, we consider the velocity of the mobile station and the RSS. For hand-out handover in open access mode, users need to handover into macrocell when the RSS is low or the velocity is fast. If the velocity is greater than V1, the next step is to check the availability of bandwidth before the user is handover into macrocell. If the velocity of the mobile station is less than V1, the RSS is checked to decide whether the user need to handover or not.

For hand-in handover in closed access mode, RSS of macrocell should be lower than threshold value or RSS of femtocell should be greater than the RSS of macrocell plus the value of the margin. If it is satisfy, the next step is to check the velocity of the UE is less than V1 and greater than V2. The handover will execute if there are availability bandwidth on the target femtocell.

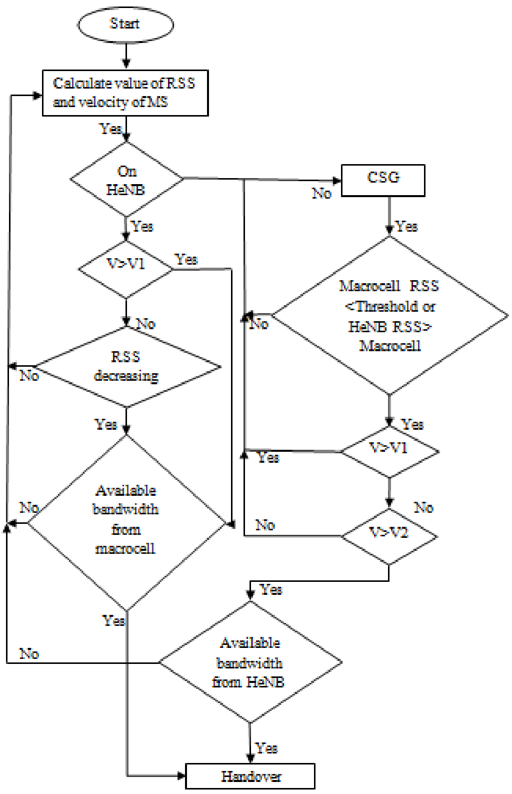

Figure 6. Flow Chart

IV. PERFORMANCE EVALUATION

A. Software Description

In this paper, the simulation was done by using MATLAB software. There are 112 macrocells and 224 femtocells developed in the simulation model. The radius of macrocell was set to 1km. Two femtocells were located in each macrocell. Call parameter, base station parameter and User Equipment (UE) parameter were generated in the simulation. Each base station is allocated with resources. After call has finish, the channel will be released by UE. The number of handover call, dropped call, terminated call, on call and blocked call will be simulate. Figure 7 shows a simulator structure when the user moved to a new location. New user is denoted by a green triangle. Figure 8 shows a simulator structure when 100 users are deployed in the cells.

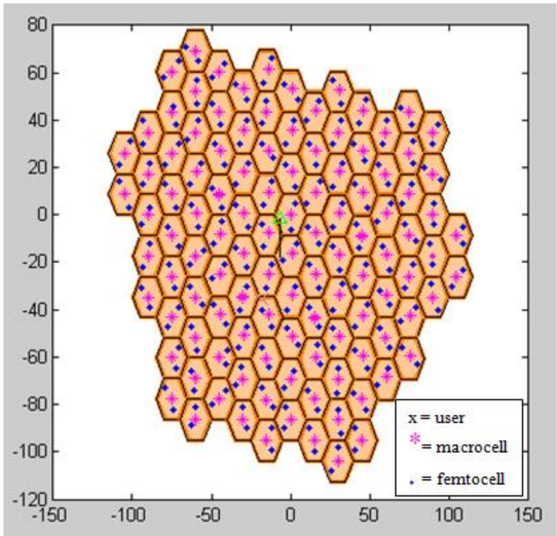

Figure 7: Simulator structure 1

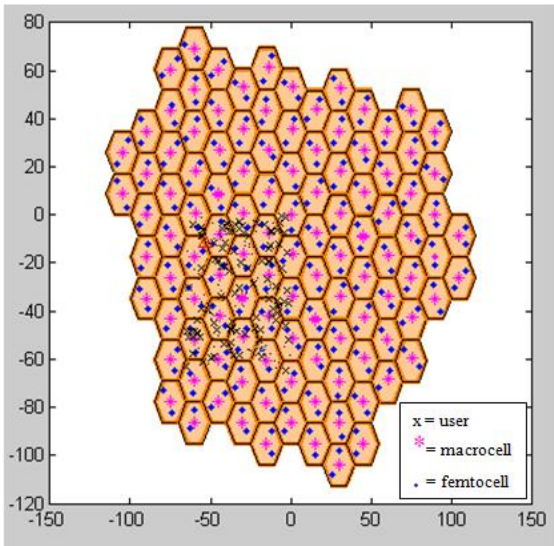

Figure 8: Simulator structure 2

B. Log Normal Shadowing Path Loss Model

In the simulation, we use Log Normal Shadowing formula to find the RSS for both macrocell and femtocell. The formula to find the Path Loss is stated in equation (1) [1].

$$PL = PL(d_0) + 10n\log(\frac{d}{d_0}) + Xg \quad (1)$$

Where:

PL = Path Loss

d_0 = close-in reference distance

d = transmitter-receiver separation distance

n = path loss exponent

Xg = a normal or Gaussian random variable

When the Path Loss is calculated, the next step is to find the RSS by using the formula as in equation (2) [1].

RSS = Pt- PL (2)

Where:

Pt = Transmit power

PL = Path Loss

Table 1 show all the parameters used in the simulation [3].

TABLE I. SIMULATION PARAMETERS [3].

Parameters	Explanation
Velocity	V1 = 25(km/h) V2 = 15(km/h)
Number of users	1-100
Cell radius	1 km
Simulation time	100-500s

C. Simulation Results

This section shows all the results from the simulation scenario. Based on the simulation scenario, we generate 224 femtocells in 112 macrocells and each macrocell contains two femtocells. All the users are generated randomly. Figure 9 shows preliminary result of the number of drop calls for different number of femtocells deployed in the macrocell. Based on the graph, it is shows that number of dropped calls are decreasing starting from one femtocell until three femtocells. The reason is because femtocell networks offer significantly better signal qualities compared to the current cellular networks due to very short communication distances [2].

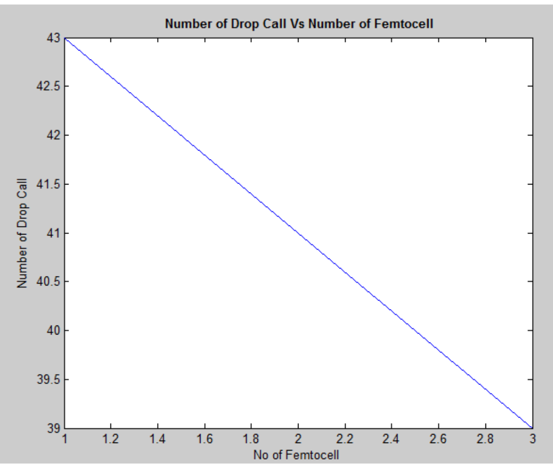

Figure 9. Preliminary result of drop call for different number of femtocells

For Figure 10, it shows that the numbers of handover calls are increasing when the simulation time is increase.

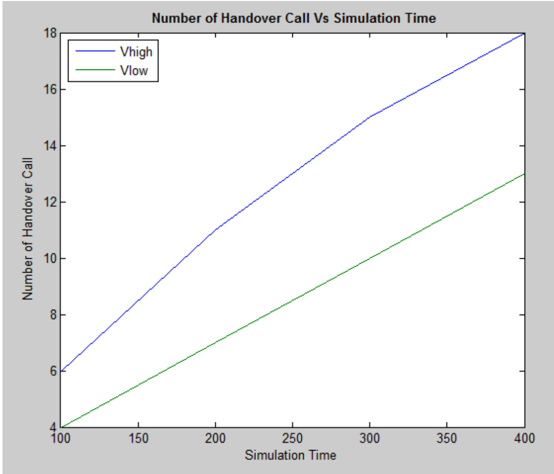

Figure 10. Comparison between number of handover and simulation time for high speed and low speed

Figure 11 shows that the number of handover calls for low and high speed. Based on the figure, it shows that this proposed procedure had proved that the number of handover is higher for high speed. This is because the threshold value for macrocell and femtocell are set with different value. The number of unnecessary handover will increase if the threshold value for both macrocell and femtocell are set with same value. Figure 12 shows the number of handover and dropped calls for high and low speed. The result shows that the number of dropped call is higher for low speed. It is because the femtocell access is limited.

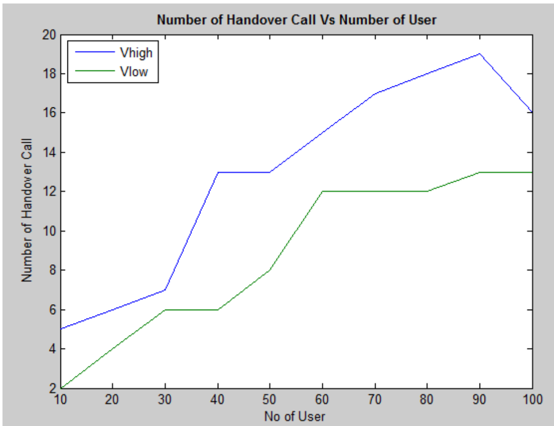

Figure 11. Comparison between number of handover and number of user for high speed and low speed

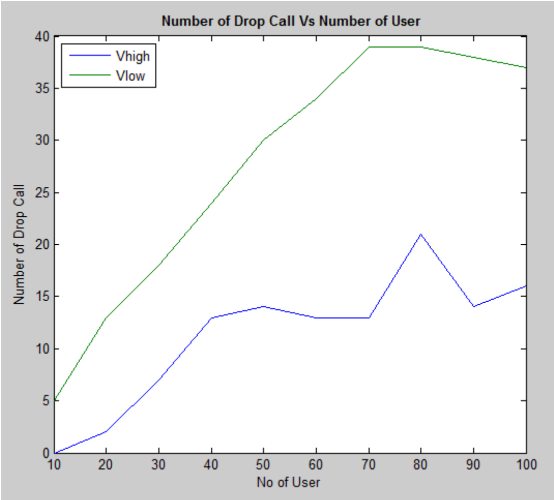

Figure 12. Comparison between number of drop call and number of user for high and low speed

TABLE II: NUMBER OF DROP CALLS FOR DIFFERENT VELOCITY

Velocity	Number of unnecessary handover
V = 20	41
V = 30	15

Table 2 shows that when the user moves from high velocity to low velocity, the numbers of unnecessary handover are decreased. This is because user does not move into femtocell. Therefore, it proved that this proposed procedure had reduced number of unnecessary handover.

V. CONCLUSION

In this paper, we analyze the handover procedure between macrocell and femtocell for two different cases. First is hand-out handover in open access mode and second is hand-in handover for closed access mode. We proposed an effective handover procedure for LTE-based network to reduce unnecessary handover. Based on the results, it shows that this method had achieved the target to reduce unnecessary handover. In the future, this work can be extended to the inter-HeNB handover and also modifying the proposed algorithm to consider interferences in LTE-based network. Besides, handover performance can be improved by proposed the adaptive threshold value for low and high speed.

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