A New Handover Strategy between Femtocell and Macrocell for LTE-based Network

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Abstract

The femtocell networks that use Home eNodeB (HeNB) and existing networks as backhaul connectivity can fulfill the upcoming demand of high data rate for wireless communication system as well as can extend the coverage area. We consider some parameters which are interference, velocity, RSS and QoS level in handover. We propose a new handover strategy between femtocell and macrocell for LTE-based network in hybrid access mode. This strategy can avoid unnecessary handover and reduce handover failure. In this paper we analyzed three scenarios after handover decision strategy procedure: hand-in (CSG and non-CSG), hand-out.

1. Introduction

As the growing multimedia, the demand for high data rate in wireless communication is increasing nowadays. In next generation the wireless communication system gradually towards to ultra-wide band technology. Today wireless communication system must face the challenges of supporting broadband data access. However, in the personal communications system according to the survey has nearly two-thirds of the service that is ninety percent occur indoor. System operators in order to improve the coverage of personal communication systems and increase system capacity, they cope with large demand for mobile devices. Femtocell is a popular method to extend mobile network coverage and enhance the system capacity. It will become a mainstream solution. Femtocell can also called home base stations, a small communication range, low power, low cost and other characteristics. It can set up by both system operators and consumers. Mainly is to make room for better-quality communication services and data transmission [1,2,9]. By using femtocell technology there will be both good for users and system operators. For users, good signal enhance the transmission reliability, capacity, and offers energy saving features such as reduced electrical interference and power wasting. For system operators it solves the shortages of radio resources and reducing the load of macrocell, and it also save the construction cost of base stations. It is estimated by 2012 there will be 70 million households in the world having femtocells, it services about 1.5 million users. Seems femtocell is very popular, but they also have lots of various challenges, including the proposed of integration architecture and access control management, security, mobility management, interference management, etc. First, system operators must integrate the architecture that already exist such as GPRS, UMTS, LTE, WiMAX and other backbone internet. The system operators will face the integration between the original network and femtocell. Smoothly interoperability with the networks, security, network monitoring software, and integration application services system, standardization/ equipment upgrades, new and old equipment compatibility issues. Furthermore, handover procedures for existing networks are needed to support the macrocell/femtocell integrated network. In a large number of femtocells, there are too many pre-handover and unnecessary handover processes frequently occur. In order to has seamless mobility between femtocell and macrocell, it is necessary dedicated on designing appropriate handover strategy [7, 8]. In the access control management, there are three femtocell access methods currently. The first is closed access mode, if you are not the CSG (Closed Subscriber Group) members, then you can't access the CSG's femtocell. Instead, open access mode is open to let everyone use. Hybrid access mode is similar to closed access mode there will have some restrictions on users of non-CSG. How to choose the appropriate access mode and the proper management are also very important. As femtocell emphasis on the convenience on building, it will not have the exact coverage area planning (cell planning). The interference between femtocell and macrocell may be very serious. We must have a adaptability self-configuration network, interference cancellation, or a way to control power. To avoid / reduce the interference between femtocell to femtocell and femtocell to macrocell is also a important challenge. In order to avoid unnecessary handoff and reduce the excessive interference, we present a handover strategy between Femtocell and Macrocell base on QoS level under LTE-based network. In hybrid access mode the QoS level and other handover parameters are be considered in our method.

2. Related works

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2.1 Basic concepts of femtocell

Femtocell can provide indoor, small office coverage, capacity and provide high quality and high transmission of wireless communications services to balance the loading of macrocell. Backhaul uses broadband internet, the installation and configuration of backhaul use plug and play way. Femtocell is a low-power and small-capacity base station. The power range of femtocell is between 13~20dBm, in the same floor, the maximum coverage is about 15 to 50 meters (location and the actual environment would affect the coverage). Because floor to floor cross to thick reinforced and concrete, the signal would have high attenuation, so just only cover each of the upper and lower floors. Figure 1. is the basic structure of femtocell access. [1,3]

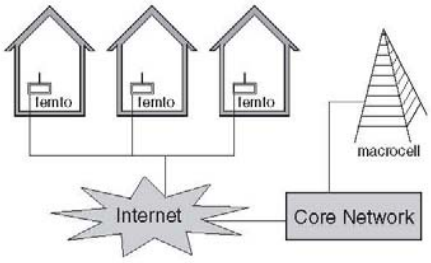

Figure 1. The basic structure of femtocell access.

The technical standard that related to UMTS-related (UTRAN) is mainly formed by 3GPP and Broadband Forum (BBF). In addition, other two agencies, Femto Forum and NGMN (Next Generation Mobile Network), are also make the contribution. Femto Forum was established in July 2007, mainly composed by mobile services and hardware and software manufacturers. In May 2008, Femto Forum's discussions, creating 3GPP in Iuh interface, and the BBF in the TR-069 family that make a significant progress. Table 1 is related terminologies for femtocell.

Table 1 .Terminologies for femtocell.

3GPP terminologies	Popular names
HNB (home NodeB) Called HNB in UMTS Called HeNB in LTE	Femtocell (FAP)
HNB-GW (HNB Gateway in UMTS) HeNB-GW (HeNB Gateway in LTE)	FAP-GW (FAP Gateway)
HMS (HNB management system)	ACS (Auto-Configuration Server)

2.2 Access control of femtocell

There are three types of access control models in femtocell: open, closed, and hybrid. The closed access mode service is only for CSG users. However, the system operator will set a different service levels for the needs of CSG users. In this case, management is more complex seems femotcell must also be able to known the user's pay level. Under open access mode, any MSs can use femtocell services. However, in mixed mode, non-CSG service can only get limited service. Of course access control mode depends on the management of system operators. Figure 2. shows the access control management. Using CSG will have CSG_id it means that you can use by a CSG femtocell Service. [5]

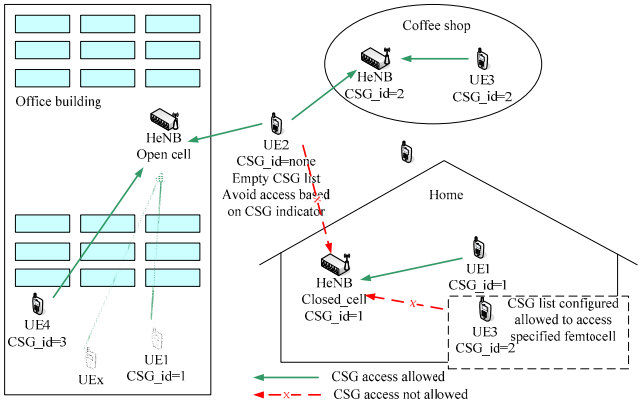

Figure 2. The access control scenario.

2.3 LTE-based network architecture of femtocell

For Femtocell and Macrocell network integration, there are some feasible choices. The E-UTRAN HeNB architecture discussed by LTE femtocell standards has not been finalized. This architecture which we want could follow the all-IP principles and integrated the evolved packet core (EPC) smoothly. The reference LTE femtocell architecture is shown in Figure. 3.[7,10]

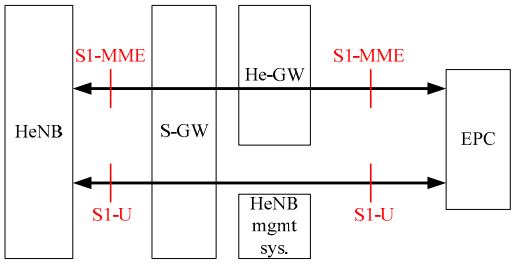

Figure 3. E-UTRAN HeNB logical architecture.

3GPP specified two standard interfaces that are X2 and S1 for the Evolved Packet System. X2 interface provides functionality to support mobility and the

exchange information between eNodeB (macrocell). S1 interface support relations between MME/SeGW and eNodeB. Furthermore, S1 is also used for the communication between HeNB and MME/SeGW. If HeNB work at control plane, it could communicate through S1-MME else the connection between HeNB and MME/SeGW could use S1-U interface for user plane. For the integration better, we could see HeNB-GW as an eNodeB for MME/SeGW view. The whole E-UTRAN architecture with HeNB is shown in Figure 4.

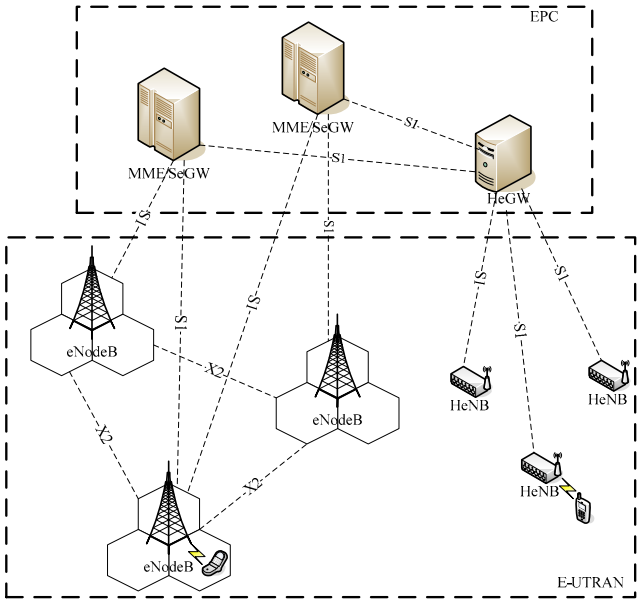

Figure 4. Whole E-UTRAN architecture with HeNB.

3. Handover strategy in hybrid access mode

3.1 Handover scenario

Handover between LTE macrocell and HeNB should operate seamless and smoothly. This is a big challenges for LTE including femtocell network. In Figure 5 we describe some cases for handover scenario in femtocell network for hybrid access mode.

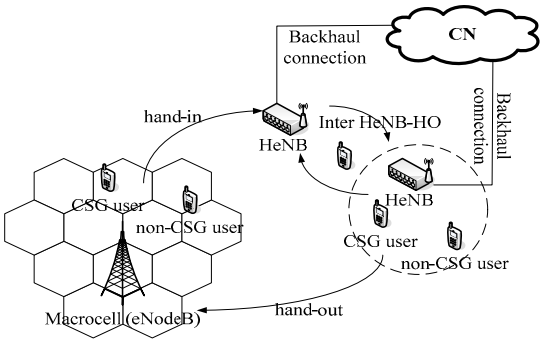

Figure 5. Handover scenario for femtocell network

First case is hand-in. This kind of handover is from macrocell serviced to HeNB. According the CSG or non-CSG user, we could divide two sub case in hand-in, those are hand-in (CSG) and hand-in (non-CSG). Second is hand-out. That represents the handover from HeNB serviced to macrocell. Third is inter HeNB-HO (handover). That describes the handover between two HeNB. But in our handover decision strategy does not discuss the inter HeNB-HO.

3.2 Interference scenario

In the femtocell network, interference is divided into the following: Cross-layer – femtocell and macrocell users interfere with each other. Co-layer – femtocell and femtocell users interfere with each other. To cope with the interference, recommends in [12] the use of power control in CMDA system and intelligent subchannels allocation in OFDM system. Co-layer interference always occurs in the two of close femtocell and without obstruction. The Cross-layer interference often occur macrocell user in the femtocell service area and both of uplink and download occurs interference. Assume our LTE base on OFDM, Figure 6 and Figure 7 describe the scenario in interference for downlink and uplink. M-user was serviced by macrocell (eNodeB) and F-user was serviced by femtocell (HeNB). In case downlink, if M-user and F-user use the same subchannels, it will cause interference in Figure 6. The desired signal need strong enough to satisfied the user, it also cause interference easily. This is similar in case uplink. [1,4,8]

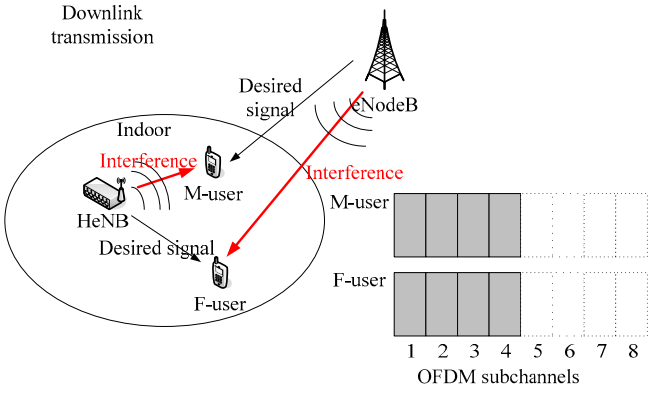

Figure 6. Interference scenario for downlink transmission.

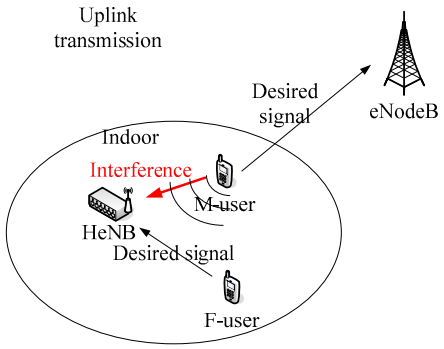

Figure 7. Interference scenario for uplink transmission

3.3 A new handover strategy

We propose a simple handover strategy in Figure. 8 under LTE-based network between femtocell and macrocell under the Hybrid access mode. The handover strategy considers with received signal strength (RSS), velocity(V), available bandwidth, QoS, and interference level. Our algorithm can decrease the interference and reduce unnecessary handover. This algorithm divide two part: Handover from HeNB to macrocell (hand-out) and Handover from macrocell to HeNB (hand-in) . We didn't discuss the handover between HeNB and HeNB (inter HeNB-HO). In case hand-in also has two sub component: one is for CSG users and the other is for non-CSG users. We design two velocity level, V_{t1} and V_{t2}, which $V_{t1}>V_{t2}$. (For example V_{t1}=30 kmph and V_{t2}=15 kmph.) System operator could set up by himself according to professional judgments. In case hand-out the consideration is simple but the management is more complex. Because of regardless of CSG or non-CSG users need to handover into macrocell serviced when they are in bad communications. Therefore, we first consider V of MS(mobile station), if over V_{t1} kmph, and check the availability of bandwidth then handover into macrocell. If MS is lower than V_{t1} kmph, use RSS to decide handover or not. HeNB physical layer characteristics can not be high-speed service. In case hand-in for hybrid access mode, first we check the user is CSG or not. If MS is CSG, see the RSS is lower than a threshold and check velocity over V_{t1} kmph or not. If $V>V_{t1}$ kmph then no handover. If Vt1 kmph$>V>V_{t2}$ kmph, see its real-time service or not. If yes, handover will be executed in availability of bandwidth. If $V<V_{t2}$ kmph, handover also will be executed in availability of bandwidth. If MS not belong in CSG, in normal situation HeNB doesn't need to service it. But if the MS cause too much interference (as you can see Fig. 6 and 7); we hope it can handover to HeNB to reduce interference. $V>V_{t2}$ kmph is not allow handover because we think this interference will pass soon. While $V<V_{t2}$ kmph and achieve interference level, handover will be request. This handover is different with normal situation, handover is initiating by HeNB.

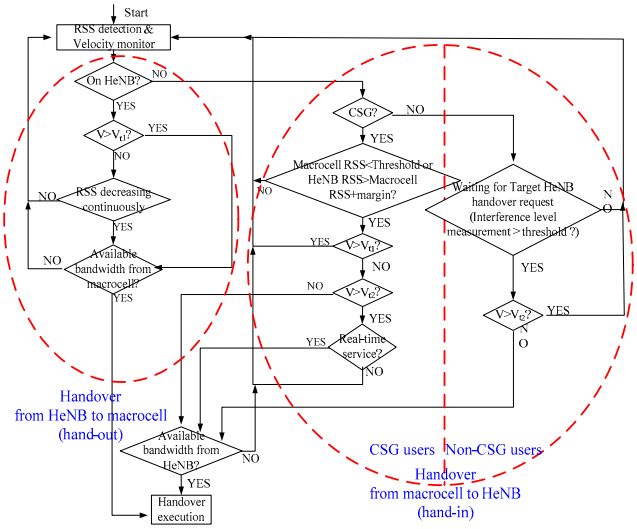

Figure 8. The new handover strategy

4. Handover procedures

4.1 Hand-in procedures

The handover from macrocell to femtocell has two kind procedures. First is for CSG. Normally, the MS should to choose the most appropriate target HeNB. It be shown in Figure 9. And for non-CSG, the handover procedures has some different with normal situation. The initialization of handover is trigger by HeNB. As you can see Figure 10.

4.2 Hand-out procedures

The procedures are uncomplicated. The procedures for hand-out can be shown in Figure.11[10, 11]

5. Conclusions and future works

In this paper, we propose a simple and effectively handover algorithm for LTE-based femtocell networks. It could reduce unnecessary handover initialize and eliminate the cross-layer interference. But we do not consider the co-layer interference and inter HeNB HO.

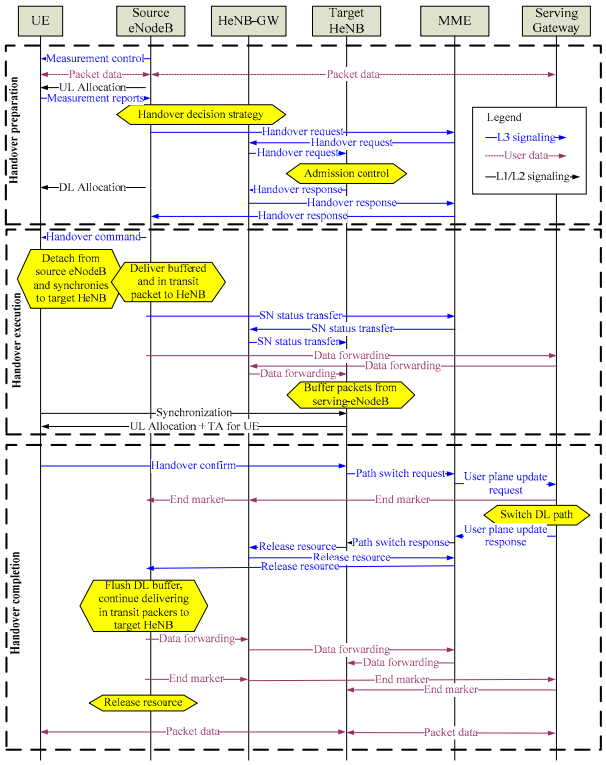

Figure 9. The hand-in procedures for CSG users

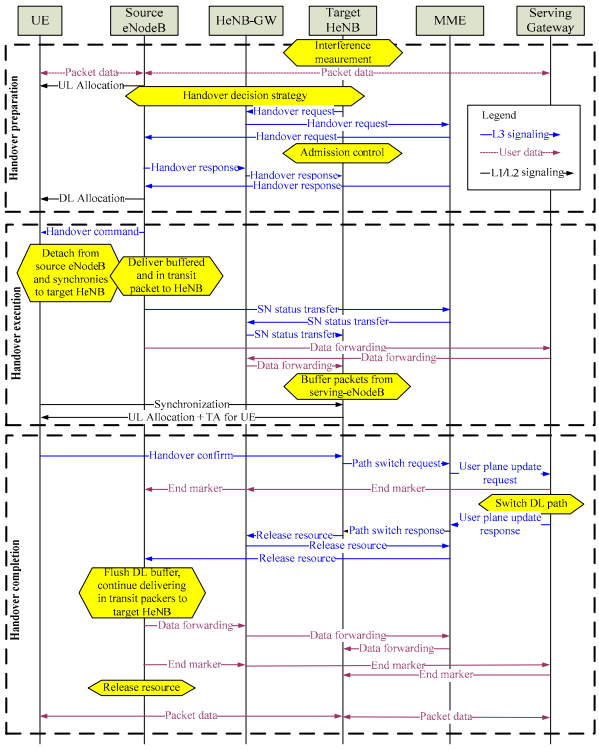

Figure 10. The hand-in procedures for non-CSG users

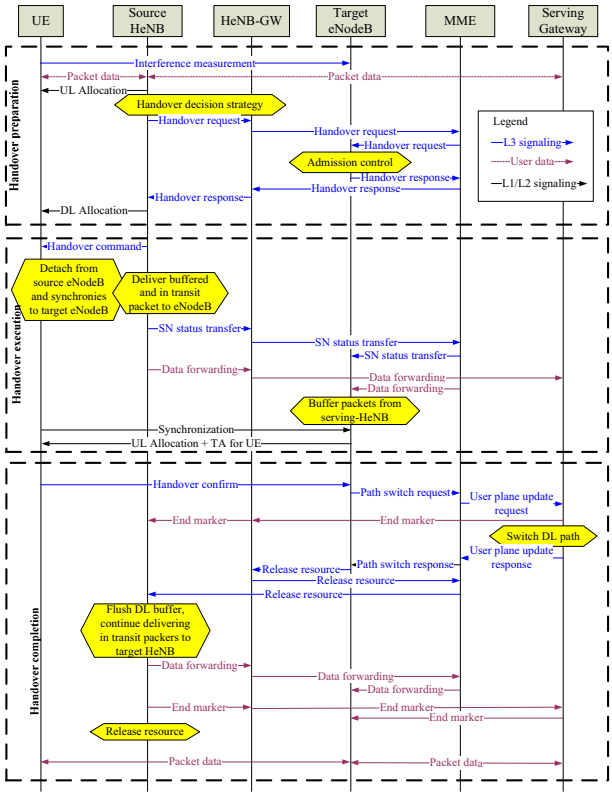

Figure 11. The hand-out procedures

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