Performance Analysis of Handover Strategy in Femtocell Network

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***Abstract*—**Femtocells, as known as HeNB is the tremendous network technology in the Long Term Evolution (LTE) network in order to fulfill the upcoming demand of high data rates. However, Femtocells deployment may cause the incidence of frequent and unnecessary handover due to the movement of the user. As Femtocells coverage area is very small and deployed randomly, there are many possible targets Femtocells for handover. This paper analyzed on the performance analysis of handover strategy in Femtocells network under Hybrid Access Mode to minimize the unnecessary handover. The handover strategy for three different threshold stay time with considering the velocity of user equipment (UE) in the mobility are analyzed. The simulation results showed that the proposed algorithm minimized the number of handover and decreased the unnecessary handover probability. Simulation results indicate that the proposed algorithm has a better performance as compare with the traditional strategy

***Index Terms*—**femtocells, handover, hybrid access mode, threshold stay time, velocity.

I. Introduction

Nowadays, the recent dramatic growth in mobile traffic requires new wireless communication systems that increase network capacity. LTE is one of the tremendous technologies for future deployment of cellular networks and wireless communication system that increase network capacity. The development concept of home base stations, so called Femtocells have come into the spotlight as a solution to improve the quality of services and to increase data rates in residential or enterprise environments.

The LTE Femtocells is small home base station represented by a Femtocells Access Point (FAP), which is supposed to be deployed especially indoor (e.g. in households, in offices, or in shopping centers). Femtocells are a low-power access point in a building that combine wireless mobile and Internet broadband technologies as shown in Fig. 1. The FAPs is connected to an operator's backbone via a wired line such as xDSL or optical fiber [1] to the cable modem. The main purpose of the FAPs are to improve signal quality indoor or in shadowed areas, to increase throughput in areas with high density of users, and to offload the Macrocell Base Stations (eNB) [2]. Femtocells allow service providers extend service coverage indoors, especially where access is limited or unavailable. It generates mobile phone signal and connected to the Internet through a network operator. Standard of LTE Femtocells has been discussed in the Femto Forum [3] and 3GPP releases [4]-[7].

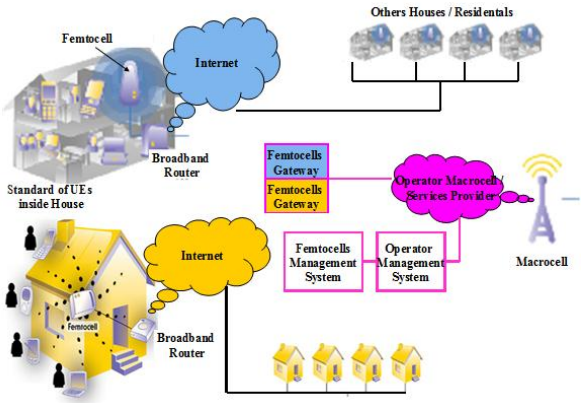

Figure 1. Typical femtocells deployment scenario

There are some issues in order to integrate Femtocells/Macrocell, since the existing cellular networks architecture is very different from Femtocells architecture. This paper focused on the handover issue in three ways of scenarios Femtocells handover procedure, i.e., Macrocell to Femtocells handover (Hand In), Femtocells to Macrocell handover (Hand Out) and Inter-Femtocells handover procedure based on 3GPP LTE specification [7] as shown in Fig. 2.

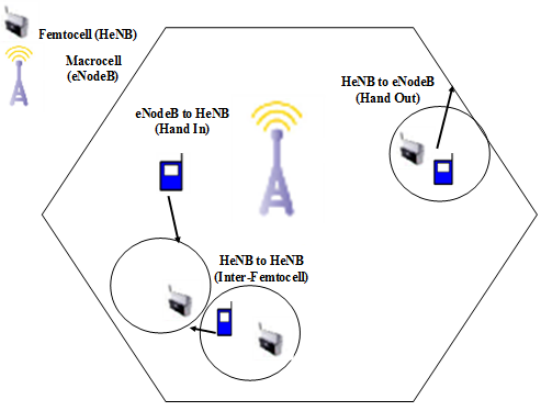

Figure 2. Handover scenarios in femtocells network

The handover procedure is related to the Femtocells Access Mode. There are three access modes which allow

Manuscript received June 10, 2013; revised October 14, 2013.
This work was supported by the e-Science grant no. 01-01-01-SF0407 funded by the Ministry of Science, Technology and Innovation and Faculty of Electrical Engineering, Universiti Teknologi MARA.
doi:10.12720/jcm.8.11.724-729

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users to access Femtocells i.e., Open Access Mode, Closed Access Mode and Hybrid Access Mode as shown in Fig. 3. Any mobile user trying to access the Femtocells service is allowed to do so in Open Access Mode without any discrimination or extra charge similar to the Macrocell. Network Service Provider mostly, deployed an Open Access Mode to enhance their coverage area and QoS. Closed Access Mode is deployed by Organizations, Offices for their use and good reception of the mobile service. There are two types of user in the Hybrid Access Mode, Registered users and Un-Registered users. Registered users have the priority to use the Femtocells services [8] while Un-Registered users can also gain access in the case that there is surplus bandwidth. The Hybrid Access Mode allows the number of unnecessary handover to be reduced and more flexible than the Open Access Mode and the Closed Access Mode [1].

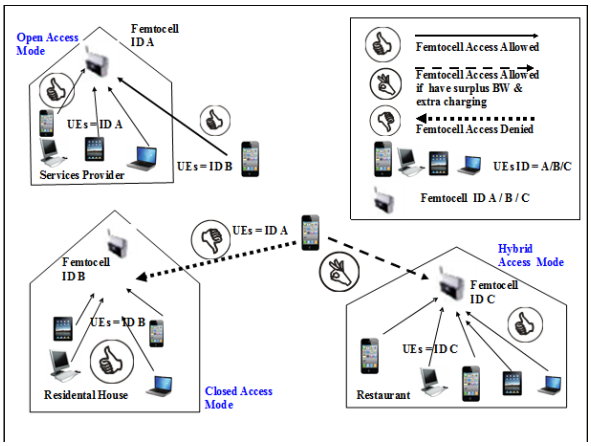

Figure 3. Services access mode permission in femtocells scenario

There are many possible target Femtocells for handover as Femtocells coverage area is very small. User's with a high velocity will cross the Femtocells in a short time whenever a high speed MS enters into Femtocells coverage area. Considering the user's QoS, the high speed user may be not necessary to execute handover. The proposed handover strategy is related to the specific threshold stay time UEs stay in a Femtocells area under Hybrid Access Mode and the velocity environment scenes. UEs in slow walk and riding a bike are being considered low and medium state velocity of user respectively which is below than 30km/h [9].

Several research works in the Femtocells network have been published. The handover algorithm between Macrocell/Femtocells for LTE based network under Hybrid Access mode has been done in [10]. The author analyzed three scenarios after decision strategy procedure which is hand-in (GSC and non-GSC), hand out. The proposed algorithm shown, could avoid unnecessary handover, reduce handover failure and eliminate the cross-layer interference. However, the author only focused on designing the strategy and designing the handout and hand in procedure without analyzing it using simulation software.

In paper [1], the authors pay attention to the spectrum access and handover strategy in two tier Femtocells network. The author focused only to one type of handover scenario which is handover from Macrocell to Femtocells area. Here, new algorithm of Call Admission Control (CAC) has been purposed considering the Received Signal Strength Indicator (RSSI) and Signal to Interference Level (SINR) level. From the simulation result obtained, the authors found that with proposed CAC, the number of handover rate is minimized and decreased the unnecessary handover probability. At the end, the author concluded that the interferences suffered by primary user in a two tier Femtocells network can be reduced using proposed dynamic spectrum allocation approach hence, proved that the proposed algorithm can reduced the load switching network.

The authors in [11] proposed the handover procedure for voice call services between the Macrocell and the Femtocells area and CAC for the Hybrid Access Mode. The differentiated treatment of the threshold time between the pre-registered user and the unregistered users is focused in the research. The simulation results for the proposed mechanism showed the number of handovers is reduced as the threshold time interval increases. The author proved that CAC proposed is effective to prevent the unnecessary handover.

In paper [9], the authors overviewed the handover procedure between Femtocells and Macrocell. The algorithm based on the UE speed and Quality of Services (QoS), is proposed. Three different velocity environments have been considered in the algorithm i.e., low speed (0 to 15 km/h), medium speed (15 to 30 km/h) and high speed (> 30km/h). The authors considered the real time and non-real time traffics as QoS parameters. The proposed algorithm has a better performance than traditional handover algorithm as shown in the comparison analysis in order to reduce the number of handover.

Overall, they found and proved the parameter setting, new CAC algorithm and stay time interval can improved the performance of handover. However, UE mobility such as velocity and moving direction varies from hour to hour in actual environment. In the situation with such changes, their optimization method for a fixed UE velocity may not provide the optimal parameter setting. Hence, it is necessary to develop a handover strategy to deal with such realistic changes [10].

The rest of this paper is organized as follows: in section II, the handovers algorithm between Macrocell to Femtocells, Femtocells to Macrocell and inter Femtocells under the Hybrid Access Mode has been proposed to minimize the unnecessary handovers. The simulation result for the proposed algorithm is discussed in section III. Finally, Section IV concludes this paper.

II. Methodology

Developing algorithm in Matlab Software is proposed in this paper. The program is designed and modified to

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model a cellular network. The basic parameters of the simulation are set as listed in the Table I. Fig. 4, shows the flowchart of handover strategy under the Hybrid Access Mode of Femtocells Network within the cellular Macrocell coverage area in LTE. In the simulation, we assumed 50 numbers of UE distributed uniformly with random velocity as shown in Fig. 5.

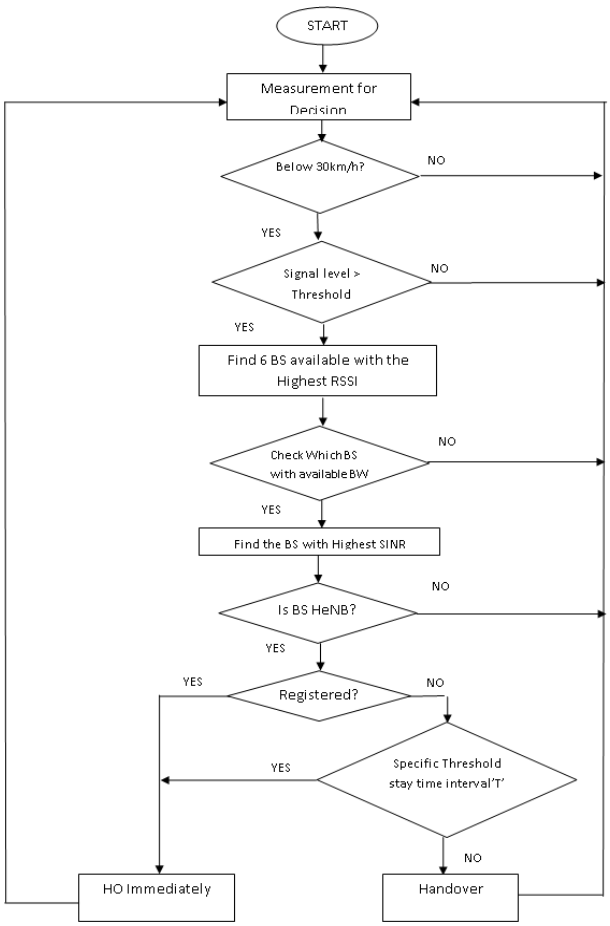

Figure 4. Proposed handover strategy in hybrid access mode

This proposed handover strategy consideres RSSI, the velocity of the UE, the SINR, the capacity bandwidth that one Femtocells can accept, the user type and the duration UE maintains the signal level above the threshold level. The threshold is the minimum level required for the handover from Macrocell to Femtocells [12].

This proposed strategy will start by monitoring the 50 UE moving from Macrocell to the Femtocells/Macrocell area. If the velocity of UE moving were below than 30km/h, they are allowed to go to the next procedure. Six Base Stations (BS), Macrocell/Femtocells with the highest available RSSI are determined. The BS which can support the bandwidth as well as having the highest SINR will be chosen. If the BS chosen is Femtocells, and the UEs are Registered, handover will immediately occur. The threshold time interval (T) for handover is set to 0 when the Registered users move from Macrocell to the Femtocells.

Registered users apply the monitoring window in 50 second while Un-Registered UEs must stay in the Femtocells area for the threshold time interval, "T" to go on to the next handover procedure. Handover can occur if the UEs stayed close by distance or still in signal level in Femtocells area and recorded in 50 second monitoring window. Else, waiting list and monitoring list are then initialized. If any Registered or Un-Registered users bounced back within 50 second monitoring, the unnecessary handover updated and the probability of handover is calculated. Otherwise, it is a normal handover process.

TABLE I. SIMULATION PARAMETER

Parameters	Explanations
Cell Shape	51 Hexagon cells 51 Macrocell BS 1020 Femtocells BS (deployed randomly)
Radius of Macrocell	1 km
Radius of Femtocells	20 m
Tx Power of Macro BS/Femtocells BS	46dBm / 20dBm
Velocity of the UEs (50 UEs)	0 to 30km/h and above 30km/h
Threshold Stay time	0, 10, 20 sec

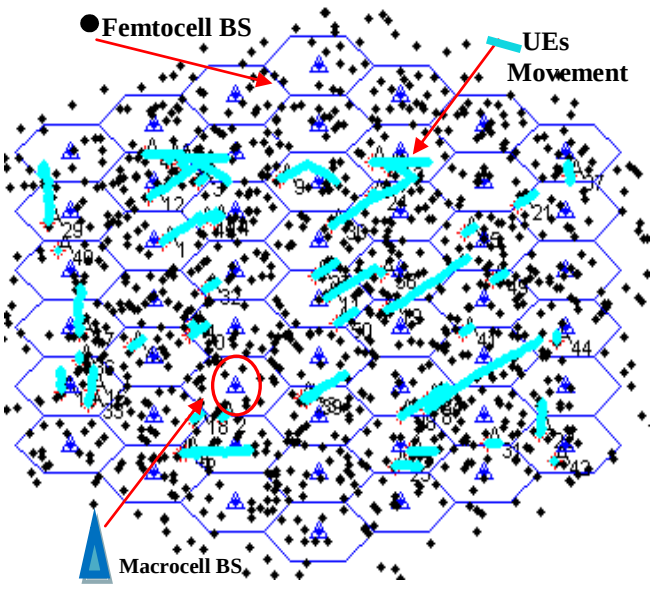

Figure 5. Simulator structure

III. PERFORMANCE ANALYSIS

Simulation performance of the proposed handover strategy procedure is performed. The time UE stays in Femtocells is calculated based on the random speeds with mean 2.7m/sec. We assume that there are 1020 Femtocells BS in the proposed topology. When Registered user moves from Macrocell into the Femtocells, the threshold time interval for handover is set to 0. Figure 6, shows the number of handovers is further reduced in the proposed algorithm of handover strategy as the threshold time interval increased from T=10sec to T=20sec.

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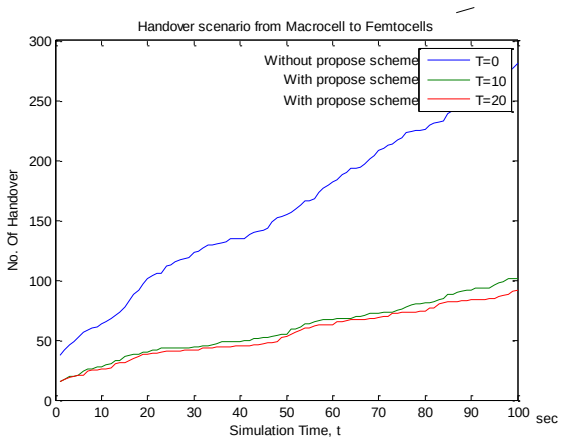
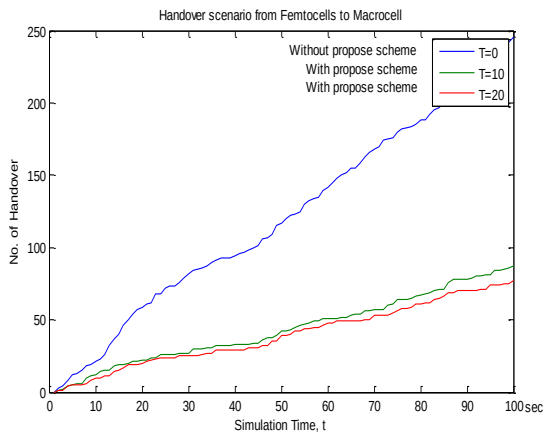
The algorithms proposed for the handover strategy under Hybrid Access Mode, have a good performance for all scenarios especially in Hand In and Hand Out scenario. Fig. 6(a), shows the number of handovers for user moving from Macrocell to the Femtocells. The proposed handover strategy resulted that, as the threshold stay time interval increases from T=10sec to T=20sec, the number of handovers is further reduced.



(a)



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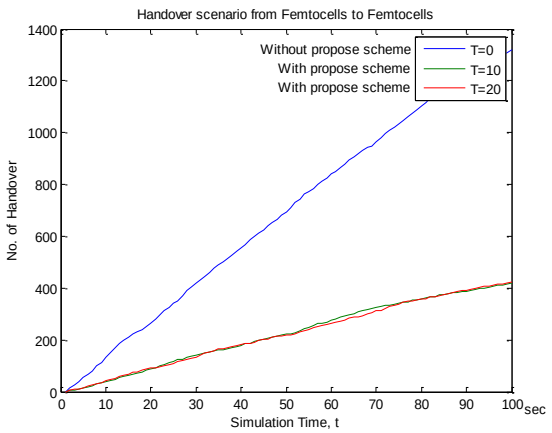

(c)

Figure 6. The number of handovers for UE moving from (a) Macrocell to Femtocells coverage area (b) Femtocells to Macrocell coverage area (c) Femtocells to Femtocells coverage area under Hybrid Access Mode.

Scenario shown in Fig. 6(b) is where a handover occurs from the Femtocells to the Macrocell or standard cellular network. Handover procedure from FAP to Macrocell (eNodeB) is relatively uncomplicated. As discussion, the UEs have no option to select the target cell since there only the eNodeB. When the RSSI from eNodeB is stronger than FAP's RSSI, the UEs will connect directly to Macrocell.

Fig. 6(c), shows the number of handovers for user moving from Femtocells to the Femtocells. The proposed strategy shows the number of handover in the Inter-Femtocells scenario is further reduced, with the highest total number of handover compared to Hand In and Hand Out scenario, as the threshold stay time interval increases from T=10sec to T=20sec. Fig. 6(c) stated that almost 1400 of handover during simulation time occurred when the propose scheme are not implemented, at T=0.

The minimization of the probability of unnecessary handovers with respect to the total handover is shown in Fig. 7. An unnecessary handover occur when a UE first moves from the Macrocell to the Femtocells and within 50 seconds for Registered UE, it bounce back to the Macrocell again or within 10 seconds for Un-Registered UE. Result clearly prove the probability of unnecessary handovers for Un-Registered users without propose scheme is about 50 ~ 60% and it is reduced to around 40% ~ 50% at 'T=l0sec' and 'T=20sec,' respectively as shown in Fig. 7.

Thus the differentiated treatment of the threshold stay time interval between the Registered and the Un-Registered UE reduces the amount of unnecessary handovers and provides better service quality and flexibility compared to the open access mode and the closed access mode [13].

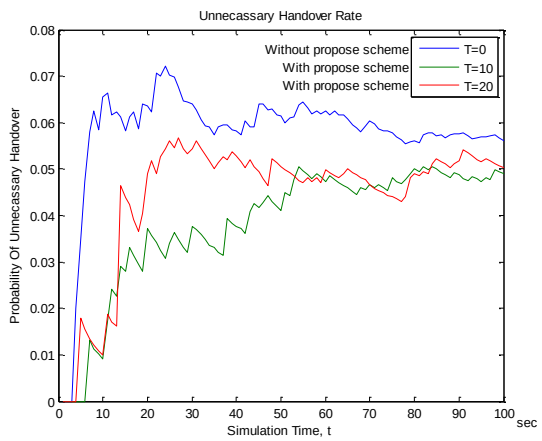

Figure 7. Unnecessary handover probability

IV. Conclusion

In this paper, the Femtocells handover strategy were proposed and analyzed. The handover strategy was evaluated based on the specific stay time interval 'T' and UE velocity. The simulation results show that the proposed algorithm gives the better result and achievement to minimize the unnecessary handover.

For the future work, the performance comparison of handover procedure by three types of access mode: Open

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Access Mode, Closed Access Mode and Hybrid Access Mode by considering the load balancing and access control management will be analyze.

ACKNOWLEDGMENT

This paper is part of research work that supported by the e-Science grant no. 01-01-01-SF0407 funded by the Ministry of Science, Technology and Innovation and Faculty of Electrical Engineering, UiTM Shah Alam.

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