Handover Framework in Enhanced Relay LTE Networks

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***Abstract*— Over the next few years, billions of devices will be connected to the Internet creating tremendous demand for mobile wireless capacity and ubiquitous coverage. For most of these applications mobile users desire that their connections are maintained as their devices move from one access point to another to keep up with user preference. Long Term Evolution (LTE) networks provides the best solution for providing good services, larger bandwidth and larger coverage area. But due to overload condition of higher loaded cell that is alleviated by changing the adjacent cell reselection, relaying is needed in order to extend the coverage around cell edges and high shadowing environments and increasing the capacity in hot spot. This research focuses on mobility management in relay enhanced LTE networks by using MATLAB software. The results show that the effect of attaching relay in LTE networks has improved the performance of handover and transmission power.**

Keywords- Long Term Evolution, Relaying, Handover, Load Balancing, Threshold, Traffic Load

I. INTRODUCTION

LTE is the preferred development path of GSM/WCDMA/HSPA networks currently deployed, and an option for evolution of CDMA networks. This essential evolution will enable networks to offer the higher data throughput to mobile terminals needed in order to deliver new and advanced mobile broadband services [1]. This network evolution's objectives are to provide these services with a quality at least equivalent to what an end-user can enjoy today using their fixed broadband at home and based on the GSM/EDGE and UMTS/HSPA network technologies, LTE is increasing the capacity and speed using a different radio interface together with core network improvements [2].

Relaying is one of the proposed technologies for future releases of UTRAN Long Term Evolution (LTE) networks. Relaying is a promising idea to increase cell coverage on a given data rate or to increase cell edge users' data rate [3]. Apart from their main goal of coverage extension, enabling relaying in a cellular network can also help in the provisioning of high data rate coverage in high shadowing environment (e.g. indoors) and hotspots, reducing the deployment cost of cellular networks, prolonging the battery lifetime for user equipments (UEs), reducing the overall power consumption of cellular networks and enhancing cell capacity and effective throughput. But due to increasing demand, some practical relaying solutions have been proposed [3][4].

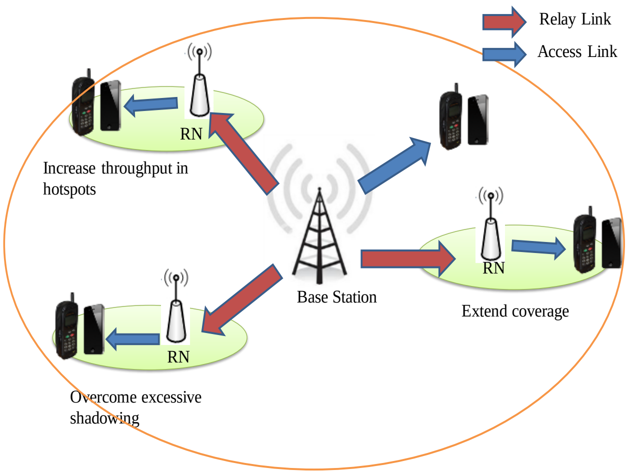

Figure 1. Example scenarios for the deployment of RNs in LTE network.

Relay enhanced networks are expected to fulfill the demanding coverage and capacity requirements in a cost-efficient way. However, due to the low transmit power characteristic of relay nodes, their coverage areas will be relatively small in the overlaying macro cell. The idea of relays is not new, but LTE relays and LTE relaying is being considered to ensure that the optimum performance is achieved to enable the expectations of the users .Therefore, the performance of relay deployments may be limited by load imbalances, unless system parameters are properly selected. So, handover procedure has been proposed as a practical solution for this problem [5].

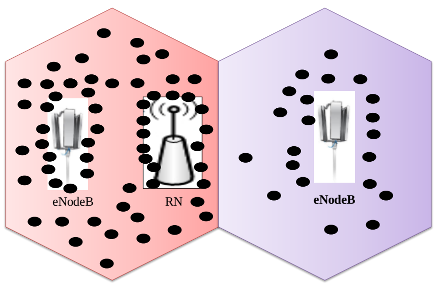

Figure 2: Relay in enhanced LTE

Many solutions' prior to this have been proposed in order to extend the coverage area by attaching RNs. One of the proposed methods is they are comparing the handover in relay LTE networks and handover in an LTE network without relaying. In an LTE network without relaying there is basically only one kind of handover, i.e. from one eNodeB to another. In a network with RNS, there is also handover between eNodeB and a RN, and between two RNs [3]. In this research, it was observed that if dynamic association between eNodeBs and RNs is enabled, there is a need to initiate handover between a RN and all the UEs. The implementation of RNs also changes the overall architecture of the network. Thus, there is a need to update the handover procedures to accommodate these changes due to increasing of possibility and complexity of handover. This research only focused on the handover between two RNs that belong to different cells. The handover in relay enhanced LTE network can be realized either in a centralized and distributed fashion [6].

Although in [7] analyze and compare the performance of three possible RNs deployments which are six relays per cell scenario, three relays per cell scenario and two relays per cell scenario. The result shows that as the more relays are attached in the cell, the performance of handover has been improved. Besides, it also can reduce the path loss.

In this paper, we proposed 19-cell system with 3 relays per cell. In section 2 the algorithm of applying adaptive the handover is describe. Section 3 explains the result and discussion of the algorithm by using MATLAB software. Lastly on section 4 the conclusion is drawn based on the result obtained.

II. METHODOLOGY

The proposed handover framework for relay LTE network is to extend the coverage especially on hot spots and locations that are highly likely to suffer from coverage loss (cell edges and high shadowing areas) It dynamically control the handover time according to the status of traffic load of the current cell. This handover parameters are depending on Receive Signal Strength (RSS) and the traffic load [8]. Based on these criteria the best serving cell can be recommended for users, ensuring a high service quality. The objective of load balancing in this system is to prevent the unbalance local traffic load between neighbouring cells and also helps to improve the overall system. When the cells are overloaded, the best solution to optimize the cell handover between the neighbouring cells is by controlling RSS threshold and traffic load parameter. So, threshold and load traffic parameter should be optimized in order to avoid the traffic congestion in relay LTE networks [9].

The proposed algorithm assumes that the cells are connected through the back bone network without any restraint of the structure. This proposed algorithm are expected to extend the coverage area and impose high system complexity without changing the mechanism itself but depending on the traffic load in both serving and target cell and the RSS threshold serving [8]. However, the traffic load in both serving and target cell and the RSS threshold serving are calculated before the simulation is begin to ensure the capability of the cell to handle the traffic.

The research focuses on developing algorithm in Matlab Software. The program is designed to model a cellular network with complete eNodeB with some user equipments. The parameter of the simulation is set as stated in the Table 1:

Table 1: Various models and simulation parameters.

Path Loss Model	Log normal shadowing path loss model
Transmission Bandwidth	10 MHz (50 PRBs)
Propagation Scenario	Macro Typical Urban (inter-site distance 1000m)
Cell layout	9 sites, 19 cells
Number of users	290 moving UEs
Relays per cell	3 fixed relays per cell
Simulation Time	250 – 2500 drops
Resource Allocation	Fixed
UE Transmission Power	[-12…………..24] dBm
RN Transmission Power	[0…………30] dBm
Transmission Power Control α	[0.6,1]
Transmission Power Control P_0 direct access	-37 dBm
Transmission Power Control P_0 relay access	-47 dBm
Parameters	α = 2, β = 0.5 THERES_TARGET = -70dB THERES_MIN = -80 dB THERES_LOADCHECK = -77 dB THERES_NORMAL = -71 dB HYS_ACCEPTABLE = 3 dB HYS_MIN = 0 dB HYS_NORMAL = 2 dB

The procedure of the handover algorithm is shown in Figure 3. In this research we need to control the transmission power to distribute traffic load of the hotspot cell and the traffic load scheme based on handover mechanism itself and there are need to control handover parameters by using threshold serving and hotspot threshold to spread the traffic load of the hotspot cell. The hysteresis is important to be control in order to avoid ping-pong effect that can decrease the number of handovers.

As shown in Figure 3, only if the threshold requirement is met, handover can be occur when mobile nodes in the hotspot cell. Traffic load can be reduced by this handover mechanism. And if both threshold serving and hotspot threshold requirement are met then the handover can be occur and can improve the utilization of system resources. This handover mechanism does not require a lot of changes over existing handover procedures and high system complexity can be avoided [10].

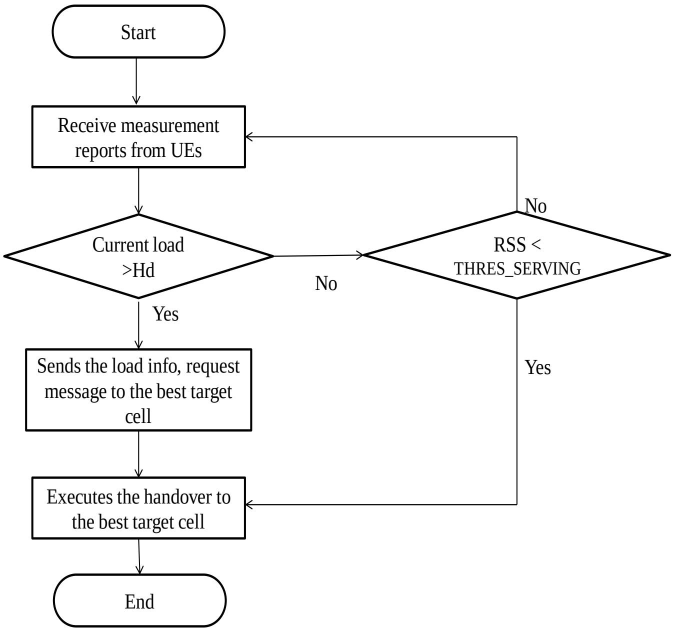

Figure 3. The proposed algorithm for the handover system

In a congested hotspot cell, an eNodeB would straight request a UE to handover to lightly loaded cell if its load reaches a hotspot threshold, Ntarget should be below than Hd. For the amount of congested resources to be hotspot, it should satisfy this equation:

$$\text{Ntarget} > \text{Hd} \quad (1)$$
$$\text{Nc(S)} > 80\%.\text{Ntotal(S)} \quad (2)$$

where, Hd is traffic load, Ntarget is the target amount of resources of current cell and Nc(S) is the amount of available resources of current cell S and Ntotal(S) is the total amount of current cell resources.

At first, the simulation will be observed by controlling the value of THRES_SERVING and will repeat by controlling the hotspot threshold, *Hd*. Existing algorithms proposed to solve the hotspot cell problem with considering the traffic load of neighbouring cells. From this simulation, the load in the current hotspot cell can be reduced by forcibly executing all possible handovers to the target cells. By controlling the amount of THRES_SERVING hotspot threshold, *Hd* the possible handovers in this scheme can be observed.

Another simulation is calculating the power control in relay-enhanced cell (REC) to observe and compare the transmission power in relay LTE networks. The power control is depending on the path losses in this system. Path losses for this system are given below. The path loss from the UE to the eNodeB (direct access link) in the LOS and NLOS cases and the probability of LOS are calculated with [5]

$$L_{LOS}(R) = 103.4 + 24.2 \log_{10}(R) \quad (3)$$
$$L_{NLOS}(R) = 131.1 + 42.8 \log_{10}(R) \quad (4)$$
$$P_{LOS}(R) = \min\left(\frac{0.018}{R}, 1\right) \times (1 - e^{\frac{-R}{0.063}}) + e^{\frac{-R}{0.063}} \quad (5)$$

where R is the distance between UE and eNodeB in meters.

The actual path loss can be then calculated with

$$L_{UE\text{-}eNB}(R) = P_{LOS}(R).\ L_{LOS}(R) + (1-P_{LOS}(R)).L_{NLOS}(R) \quad (6)$$

For the RN-eNodeB (backhaul) link, the path loss is calculated with

$$L_{LOS}(R) = 100.7 + 23.5 \log_{10}(R) \quad (7)$$
$$L_{NLOS}(R) = 125.2 + 36.3 \log_{10}(R) \quad (8)$$
$$P_{LOS}(R) = \min\left(\frac{0.018}{R}, 1\right) \times (1 - e^{\frac{-R}{0.072}}) + e^{\frac{-R}{0.072}} \quad (9)$$

For the UE-RN (relay access) link, the path loss is calculated with

$$L_{LOS}(R) = 103.8 + 20.9 \log_{10}(R) \quad (10)$$
$$L_{NLOS}(R) = 145.4 + 37.5 \log_{10}(R) \quad (11)$$
$$P_{LOS}(R) = 0.5 - \min\left(0.5, 5e^{\frac{-0.156}{R}}\right) + \min\left(0.5, 5e^{\frac{-0.156}{R}}\right) \quad (12)$$

The LTE air interface is realized with a set of physical resource blocks, among which their subsets are allocated to a certain UE. This kind of transmission scheme involves spreading the transmit power over the allocated PRBs. Therefore, the concept of a power spectral density (PSD) is introduced. The PSD defines the transmit power per PRB. Transmission power control formula for LTE and LTE-A-uplink is presented in

$$P_{TX} = \min\ (\mathrm{P}_{max}, P_0 + \mathrm{a}.PL + 10.\log M + \Delta_{TF} + f\ (\Delta_{TPC})) \quad (13)$$

where P_{max} is the maximum transmission power, P_0 is the minimum transmit power spectral density, α is the path loss compensation factor, *PL* is the net loss of the radio transmission path, *M* is the number of allocated PRBs, ΔTF is the transmission format (modulation and coding scheme) dependent term and *f*(ΔTPC) is the term that permits either accumulated or absolute corrections.

The simulations consider only open loop power control terms (*P*0, α, *PL* and *M*). Term Δ_{TF} is dependent on the adaptive modulation and coding which is not implemented as such in the simulator. $f(\Delta_{TPC})$ can be omitted because the simulator applies only one power control command to the UEs in each drop. Since the focus here is on open-loop power control, the latter two parameters are omitted and (12) is applied

$$P_{TX} = \min\ (\mathrm{P}_{max}, P_0 + \mathrm{a}.PL + 10.\log M) \quad (14)$$

In summary the first algorithm is to shrink the coverage area for the hotspot cell. The second algorithm is to observe the effect of relaying to the transmission power control of the system.

III. RESULTS AND DISCUSSIONS

Simulator consists of nine tri-sectored eNBs, which form a 19-cell system. In each cell, the relay nodes are dropped at the cell-edge. The relay deployment of this system is shown in Figure 5. In this simulation, eNodeBs as base station towers are marked as blue square, relay nodes as magenta stars, and UEs as the yellow x. The simulator creates a layout based on the parameters given in the simulator initiation. The layout is based on the inter-site distance, which dictates the base station site location. These nine sites then become attachment points for 19 different cells. The relay nodes are being placed within each cell according to the number of relay nodes set in the simulation parameters. After the cell layout drawn, the UEs are generate randomly inside the system.

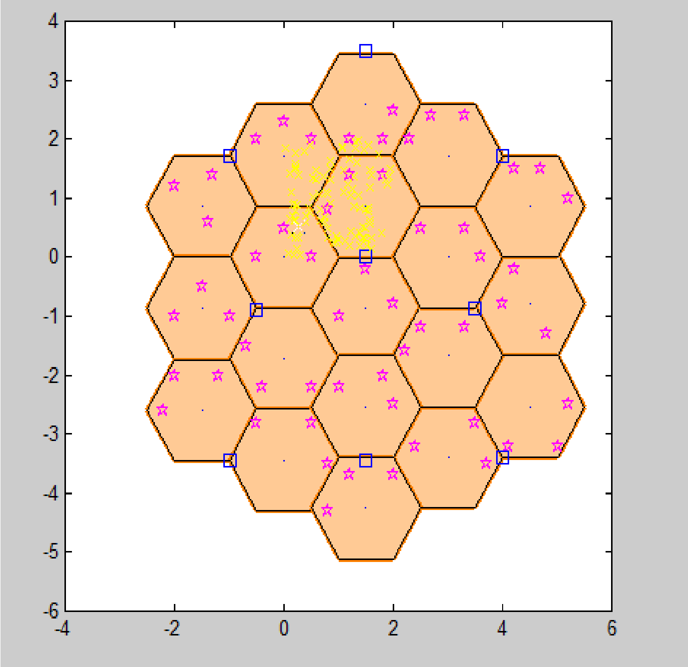

Figure 5 . Deployment of 19-cell system with 3 relays per cell and 290 UEs.

A. Effects of the THRES_SERVING on the Performance of Successful Number of Handover Calls

The result obtained after the execution of the network is presented in Figure 6. The number of successful handover calls are used to evaluate the handover performance of the simulation.

This section analyzes the effect of the THRES_SERVING for the proposed handover framework for relay enhanced LTE networks with a fixed number of hotspot threshold, Hd. Hotspot threshold, Hd in this simulation is set to be 1 The THRES_SERVING is the most important parameter in initiating the handover process. The neighor's eNodeB could not connect to the serving eNodeB if the THRES_SERVING is very low or very high.

As shown in Figure 5, the simulation results indicates the handover performance increases as the THRES_SERVING increase. The higher the THRES_SERVING, the earlier the mobile device will initiate the handover. The higher the THRES_SERVING shows that high handover calls can be performed in relay enhanced LTE networks and can help in reducing the hotspot traffic load in current serving eNodeB. From this result, the simulation shows that the optimum value for this threshold is -50dB. Therefore, it can be concluded that the proposed method can reduce the traffic load and can achieve the load balancing of this system.

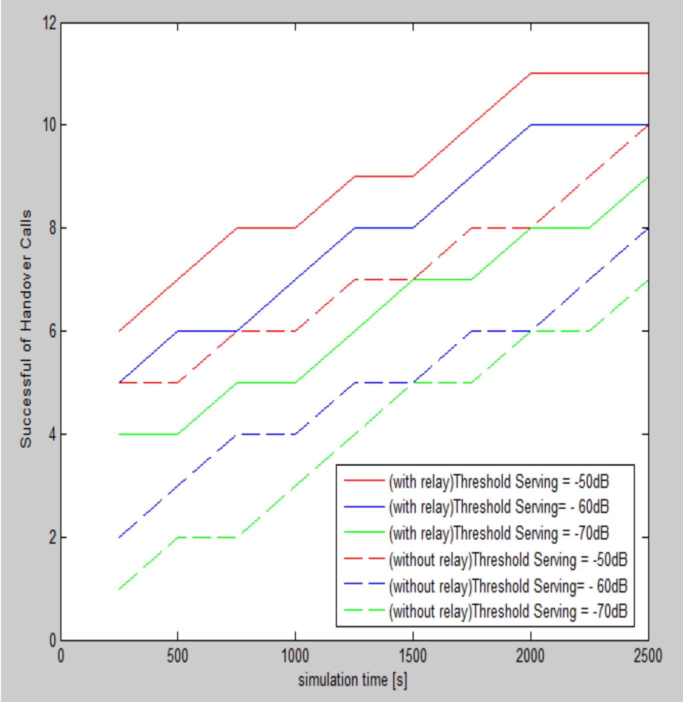

Figure 6 . Effect of the THRES_SERVING on the handover performance

B. Effects of the Hotspot Threshold, hd on the Performance of Successful Number of Handover Calls

This section analyzes the effect of the Hd for the proposed handover framework for relay enhanced LTE networks with a fixed number of THRES_SERVING. The THRES_SERVING is set to be -50 dB. The hotspot threshold is one of the important parameter in initiating the handover process. The neighor's eNodeB could not connect to the serving eNodeB if the Hd is very low or very high.

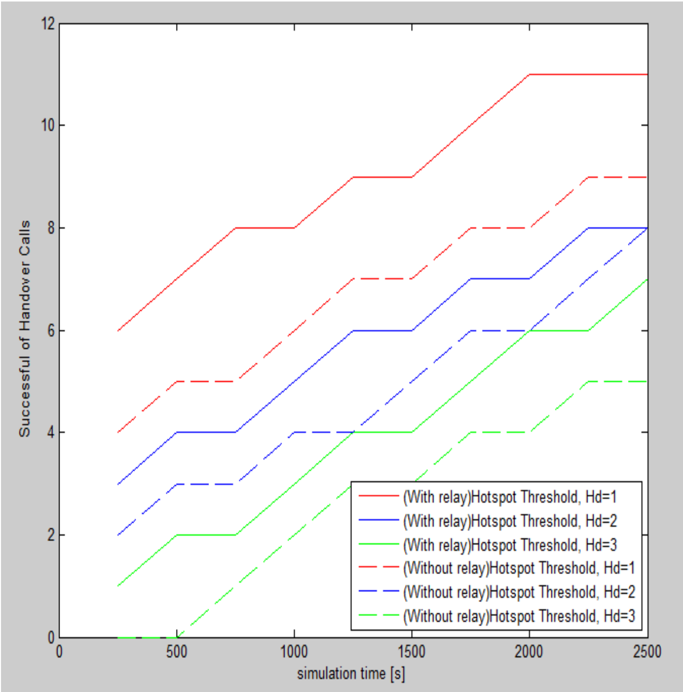

Figure 7 . Effect of the Hd on the handover performance

The simulation result is shown in Figure 7. Figure 7 shows that the effect of Hd on the performance of the handover framework for relay enhanced LTE networks. The successful number of handover calls increases as the Hd reduces. The impact of increasing the Hd will increase the traffic load hence will increase the probability of drop calls. In this systems shows that the optimum value for the Hd is 1.Hence Hd is the important parameter in order to balance the traffic load between neighboring cells and thus enhance the network performance.

C. Power Control in Relay Enhanced Cell

To determine UE overall capacity of the cellular system there is a need to control the transmission power to minimize the interference caused by simultaneous radio transmissions while maintaining the need for sufficient transmitted energy per bit to achieve the required quality-of-service because the radio frequencies and channels are always shared in some level among the users using the same system. In achieving this goal, the uplink power control has to adapt to the characteristics of the radio propagation channel, including path loss, shadowing and fast fading as well as overcoming the interference caused by other users or elements in the radio system. Interference can be caused within the same cell or neighbouring cells. So the main goal in power control is to use transmission power just enough to communicate leading to the reductions to overall interference and in transmission power, which helps increase battery life.

From Equation (14), the parameter a can take values between 0 and 1 implying the path loss. Precisely, a = 0 implies no path loss compensation (No power control) while a = 1.0 implies full path loss compensation. The flexibility in compensating for a fraction of the path loss is introduced to the power control formula to control the scaling of the transmit powers of cell-edge UEs. Since the cell-edge UEs have a higher path loss compared to cell center UEs, fractional path loss compensation would cause a higher downscaling of the transmit powers of the UEs at the cell edge.

In the simulations, P_{max} is set to be 24 dBm and P_0 is set such that 30% of UE transmit at P_{max}. The results illustrate the higher cell center UE transmit power compared to the cell edge with decreasing the a. The transmission power increases as the path loss compensation decreases.

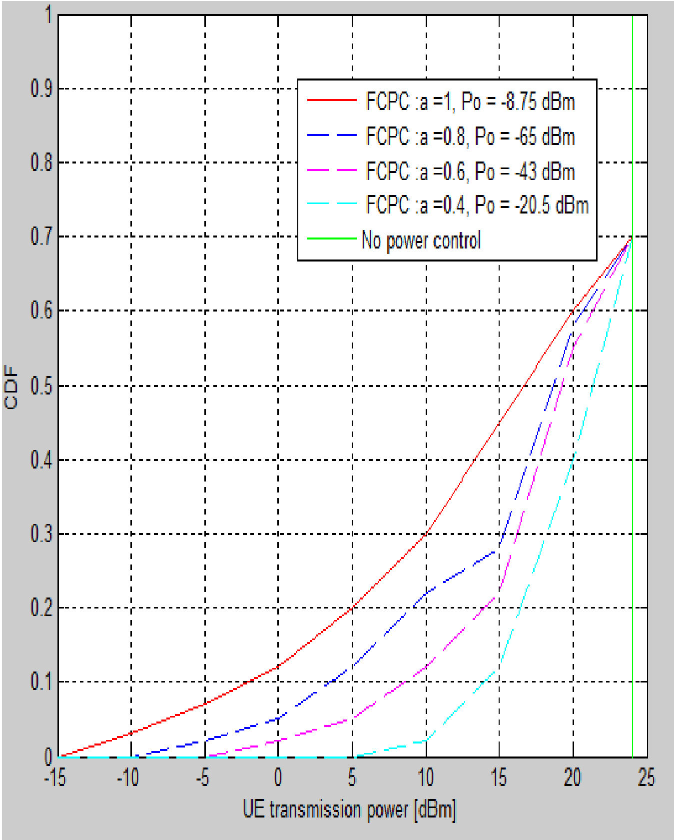

Figure 8 . Direct UE transmit power with different α and P_0 values

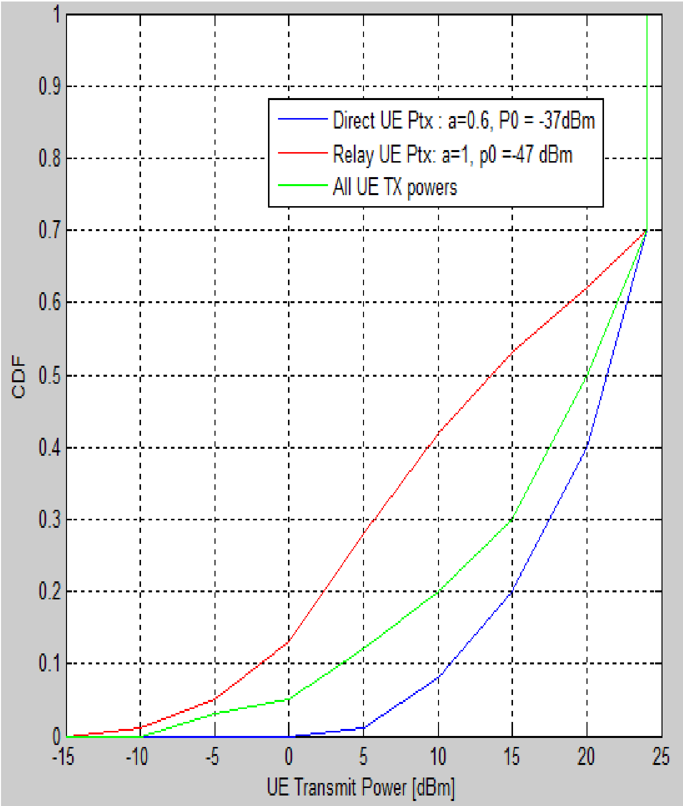

Figure 9. Direct UE and Relay UE transmit power

IV. CONCLUSION

In this paper a framework of 19-cell system is deployed with attaching 3 relays per cell for handover procedure in relay enhanced LTE networks is presented. A handover algorithm is applied in relay enhanced LTE networks in hotspot cells to reduce the traffic load in order to provide a good service. The handover performance with respect to traffic load has been evaluated by controlling the THRES_SERVING and Hotspot Threshold, *Hd.* In this research the results from the simulations suggested that the relay use offers better performance than the regular cellular system. Besides that relaying can help in increasing of transmission power control.

For future work, I suggest to increase the number of relays per cell and eNodeB to in order to extend the coverage area and to improve the handover performance in relay enhanced LTE networks. Besides that we can observe and compare the performance of throughput in relay LTE networks and LTE without relaying as the throughput is also important to overall cell system.

REFERENCES

[1] Andras Racz Andras Temesvary and Norbert Reider, "Handover Performance in 3GPP Long Term Evolution (LTE) Systems", *Mobile and Wireless Communications Summit*, pp 1-5. July1-5 2007

[2] Steele R., Mobile Radio Communications., John Wiley & Sons Ltd., 1996

[3] Oumer Teyeb, Vinh Van Phan, Bernhard Raaf, Simone Redana ,"Handover Framework for Relay Enhanced LTE Networks ",*Communications Workshops*, pp 1-5,

[4] Mattia Minelli, Marceau Coupechoux, Jean-Marc Kelif, Maode Ma and Philippe Godlewski, "Relays-Enhanced LTE-Advanced Networks Performance Studies", *Sarnoff Symposium*, pp 1-5, May 3-4 2011

[5] Aki Juntunen, "Resource Allocation in LTE-A Uplink With Relays", pp 51-79, 2007

[6] Aydin Karaer, Ömer Bulakci, Simone Redana, Bernhard Raaf , "Performance Enhancement in LTE-Advanced Relay Networks via Relay Site Planning" *Vehicular Technology Conference (VTC 2010-Spring)*, pp 1-5, *May* 16-19 2010

[7] Nurzal Effiyana Ghazali and Sharifah Hafizah Syed Ariffin ,"Handover Signaling for Mobile User in Relay LTE-Advanced Environment" ,*Control System,Computing and Engineering (ICCSCE),* pp 216-220

[8] A L. Yusof., M. Ismail.,and N. Misran., "Adaptive Handoff Algorithm in Next-Generation Wireless Systems", *IEEE International RF and Microwave Conference Proceedings,* pp. 77-80, Dec 2008.

[9] Yinghao Jin, Chong Lou, Ling Qiu, " Mobility Load Balancing in the deployment of Relay Node", *Self-Configuration Network (SON)*, pp 1-5, Jan 7-8 2011

[10] D. Kim, N. Kim, and H. Yoon, "Adaptive Handoff Algorithms for Dynamic traffic Load distribution in 4G", *IEEE The 7th International Conference on Advance Communication Technology*, pp. 1269-1274, Feb 2005

[11] R. Verdone and A. Zanella, "Performance of receive power and Traffic Driven Handover Algorithms in Urband Cellular Network", *IEEE Wireless Communication*, pp 60-71, February 2009

[12] Oumer Teyeb , Frank Frederiksen, Vinh Van Phan , Bernhard Raaf and Simone Redana , "User Multiplexing in Relay Enhanced LTE-Advanced Networks", *Vehicular Technology Conference(VTC 2010-Spring)*, pp 1-5, May 16-19 2010

[13] Aydin Karaer, Ömer Bulakci, Simone Redana, " Uplink Performance Optimization in Relay Enhanced LTE-Advanced Networks" , *IEEE Trans of Vehicle Technology*, pp 360-364, Sept 13-16 2009

[14] Hassan Hamdoun , Pavel Loskot "Scalability of Two-Way Relay Channel Network Coding in a Relay Enhanced LTE Cell", *Communications and Information Technologies (ISCIT)*, pp 168-173, Oct 12-14 2011

[15] Yi-Bing Lin and Imrich Chlamtac," Wireless and mobile Network Architectures", Wiley and Sons,2008

[16] Holma, H., Toskala, A, WCDMA for UMTS: Radio Access for Third Generation Mobile Communications. John Wiley and Sons, 2004.

[17] M.M.Khan, and M.S.Khan, "Investigation of Handovers in 3G UMT Traffic Classes", Blekinge Institute of Technology, Mac 2010