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PERFORMANCE ANALYSIS OF HANDOVERSTRATEGY IN FEMTOCELL NETWORK BYUSING FRACTIONAL FREQUENCY REUSE AND DYNAMIC POWER CONTROL METHODS

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ABSTRACT

In Long Term Evolution (LTE) network, a femtocell as known as Home Evolve Node B (HeNB) is a small base station that aims for indoor usage such as at home or enterprise in order to fulfill the upcoming demand of high data rates. It is very user deployed so it reduces operations cost for mobile operators, and at the same time provide a high user experiences to users. However, femtocell deployments caused interference between femtocells itself and also to the existing macrocells due to sharing the same frequency band between macrocell and femtocell. In order to achieve a high network capacity and a good user experience, more advanced interference coordination and radio resource management schemes would be required as compared to the conventional cellular network. Hence, the interference management methods which the are Fractional Frequency Reuse (FFR) and the Dynamic Power Control (DPC) were proposed. This paper analyzed on the performance analysis of handover strategy in macrocell and femtocell networks for balancing the network User Equipment (UE) by offload traffic from macrocell to the femtocell and hence the high load balancing of UE network can be achieved and then minimize the interference occurence in the network by using the proposed methods. The simulation results showed that the proposed combining methods give a significant reduction of number of handovers and inter-cell interference in LTE HetNets by offloading the macrocells traffic to the femtocells and higher load balancing performance can be achieved.

Keywords: long term evolution (LTE), home evolve node B (HeNB), fractional frequency reuse (FFR), dynamic power **c**ontrol (DPC), heterogeneous networks (HetNets), interference.

INTRODUCTION

Nowadays, the current intense growth in mobile traffic requires new wireless communication systems that growth 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 focus as a solution to expand the quality of services and to increase data rates in residential or enterprise environments.

LTE femtocell networks enable in-home cell phone coverage and provide access to high speed wireless broadband services, which use home base station and existing xDSL or other cable line as backhaul connectivity. It can diverse the load from LTE macrocell networks as well as reduce the operating and capital expenditure costs for operators (3GPP TS 36.300).

Femtocell is defined as low cost, low power points deployed by the end customer that provide indoor coverage of a given wireless cellular standard and they connect to the network operator through a backhaul such as fiber, cable broadband connections and digital subscriber line (DSL) (Gang *et al.,* 2011). The basic system of femtocell is providing connectivity between local mobile phones and internet router. There are several items that needed such as femtocell itself, internet router to enable the data to be passed to and from the femto via the internet, an internet link and mobile telecommunications service provider core network gateway (www.radioelectronic.com). On the other hand, the radio coverage over a varying distance that is provided by macrocell is dependent on the frequency used, the number of calls made and the physical terrain. The deployment of the femtocell is the solution for this problem.

The femtocells are needed for LTE because of coverage problem and report showed that 70 to 80 percent of mobile traffic is generated at home or in the office (www.radioelectronic.com). LTE femtocells were deployed to enhance the LTE coverage and ensure that more users (for home it can support 3 to 5 and for enterprise can support 8 to 16) have access to the peak LTE throughput most of the time (Jie*et al.,*2010). LTE femtocell will replace WI-Fi modem since most femtocell has built in Wi-Fi. A femtocell is basically a personal cell phone tower which is the size of a Wi-Fi router that reroutes all of cell calls through broadband internet connection. The femtocell access to the core mobile Network via broadband internet is shown in Figure-1.

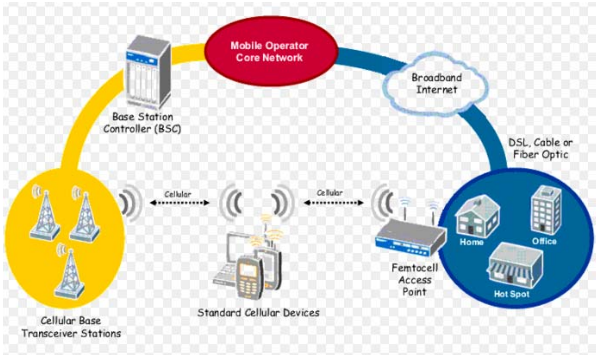

Figure-1. Femtocellaccess to the core mobile network via broadband internet (www.juniper.net).

Since the current cellular network architectures is very dissimilar from femtocell architecture, so there are some problems in order to mitigate the femtocell/macrocell network. This paper focused on the handover issue in two ways of scenarios femtocells handover procedure which are the handover from macrocell to femtocells and also femtocells to macrocell handover.

Interference management issues for the femtocell systems have been aggressively discussed in the LTE network nowadays. As the technologies growths from 1G to 4G, there are frequent readings obligate tried to describe as well as study the interference mitigation in a network through analysis of SINR performance. Based on the previous researcher's work, various interference management strategies have been proposed to address this issue including for instance, location dependent power setting (Vikram *et al* 2009), fractional frequency reuse (Heui *et al* 2010) (Thomas *et al*., 2010) and through the power control (Marceau *et al* 2011).

Motivated by the accomplishment from (Chang *et al* 2011), (Akindele *et al* 2012), (Zainul *et al*., 2013) and the limitation of the author's work, the researcher goes advance towards study the performance of interference management in LTE which improves the network performance by offloading the macrocell traffic to the femtocell and hence the higher load balancing network can be achieved as well as can minimize the interference effect by reducing the number of handovers.

The authors of (Azita *et al.*,2013) studied the handover adaption for load balancing scheme in macrocell/femtocell LTE network. The paper proposed a modified handover procedure for macrocell and femtocell network. However, the authors studied the handover algorithm based on Received Signal Strength (RSS) and speed of the UE to improve the handovers between the macrocell and femtocell in LTE network. The result shows that the unnecessary handover and handover failure can be optimized using modified handover in this macrocell and femtocell integrated network.

In (Noor *et al* 2012), a load balancing scheme that can control the handover time based on the load status of cells was studied. The authors said that the scheme requests the load information of the target cell in advance to avoid handover to an overloaded target cell. From the simulation results, it showed a significant reduction in dropped calls rate which can manage overloaded traffic in the system.

Besides that, the performance of intra and inter handover with overlapping cell in LTE based network was proposed in (Melati *et al* 2013). The authors was analyzed the performance of intra and inter handover based on the probabilities of false initiation handover as well as the probabilities of handover failures when the overlapping occurred. The simulation results showed that probabilities failure is directly proportional to the speeds for both handover types. The intra handover has a better performance than inter handover because inter handover needs more time to make a new registration.

The rest of this paper is organized as follows. Section II introduces the methodology of the handover strategy by using the proposed methods. The performance evaluations are carried out to analyze the performance of the handover analysis for both macrocell and femtocell networks in Section III. Finally, conclusions are drawn in Section IV.

METHODOLOGY

This paper focuses on the performance analysis of handover strategy in femtocell network by using FFR and DPC methods. The main objective of this study is to balance the network User Equipment (UE) by offload traffic from macrocell to the femtocell and hence the high load balancing of UE network can be achieved and then minimize the interference occurence in the network by using the proposed methods.

In order to evaluate the performance of the handoff algorithm, a framework has been built using MATLAB software with few assumptions. The topology structure of macrocell and femtocell is shown in Figure-2.

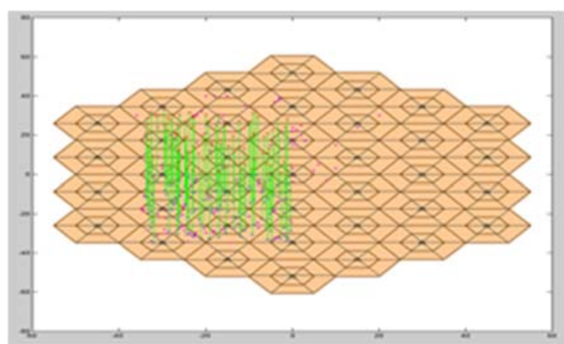

Figure-2. Topology structure of macrocell and femtocell.

The deployments of a handoff algorithm for macrocell and femtocell in LTE network is based on the simulation parameters shown in Table-1. The program was designed and modified to model a cellular network. Figure 3 shows the flowchart of handover strategy under the macrocell and femtocell LTE network. Under simulation model, we assumed 100 numbers of UE where distributed uniformly with setting into two different type of speeds

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which are the low speed and the high speed. This proposed handover strategy was started by measure the SINR and speed of UE followed by checking the location of UE. If UE located in femtocell Base Station (BS), checking the UE speed. If the speed of UE moving were below than 30km/h, they are allowed to go to the next procedure. Next is checking the target channel with the femtocell traffic threshold value. Six BS, Macrocell/Femtocells with the highest available SINR are determined. The BS which can support the bandwidth as well as having the highest SINR will be chosen. If the BS chosen is femtocell, the SINR threshold satisfied then the handover will occur to another femtocell. Same steps also applied to the macrocell.

Table-1. The simulation parameters.

Parameter	Setting
Number of UE	100
Number of MBS	37
Number of FBS	60
MBS Transmit Power	46dBm
FBS Transmit Power	20dBm
Radius of Macrocell	10km
Speed of UE	5-120km/h
Simulation Time	200s-2000s
Target SINR for Macrocell (Γm)	60dB
Target SINR for Femtocell (Γf)	25dB
Average Uplink Interference for Macrocell (Im)	40dB
Average Uplink Interference for Femtocell (If)	20dB
Path Loss Compensation Factor (α)	0.9
Number of Assigned Resource Cluster for Macrocell (Mm)	80
Number of Assigned Resource Cluster for Femtocell (Mf)	25
Traffic Threshold Value for Macrocell (Hd1)	0.4
Traffic Threshold Value for Femtocell (Hd)	0.2
Availability Channel for Macrocell (Ntarget1)	100
Availability Channel for Femtocell (Ntarget)	20
Handover Macrocell Threshold Serving Value	165dB
Handover Femtocell Threshold Serving Value	140dB
Cell Layout	Hexagonal grid, 6-sector per cell

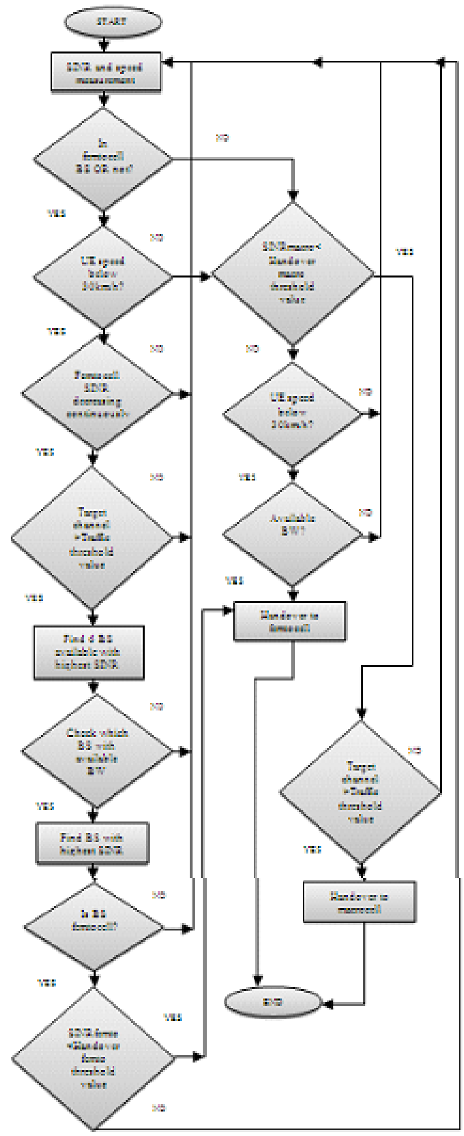

Figure-3. Handoff flowchart.

PERFORMANCE EVALUATION

A) The effect on number femtocell deployed with the number of femtocell handover for 100 UE (Low speed)

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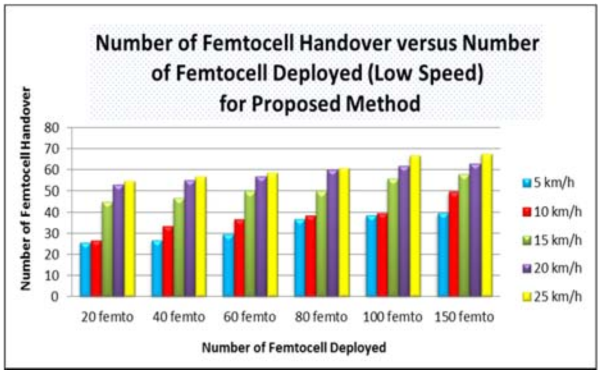

Figure-4. Number of femtocell handover vs number of femtocell deployed (Proposed method for low speed).

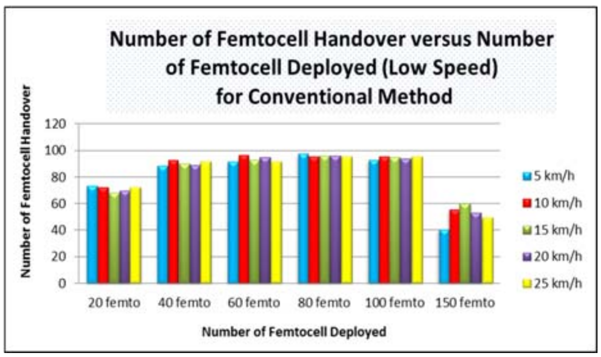

Figure-5. Number of femtocell handover vs number of femtocell deployed (Conventional method for low speed).

Figure-4 and Figure-5 discuss the number of femtocell handover arisen when dissimilar number of femtocells was deployed for five different low speeds for proposed and conventional method correspondingly. The number of femtocells varies are 20 femtocells, 40 femtocells, 60 femtocells, 80 femtocells, 100 femtocells and 150 femtocells for 100 UEs and the UE speeds were set from 5 km/h, 10 km/h, 15 km/h, 20 km/h and 25 km/h. According to outcome in Figure-4, it shows that as increasing the speed of UE, the increasing the number of handover will be initiated. The handoff would initiate a faster time as the faster the UEs speed. Also, as equated to the number of femtocell handover for the conventional method as illustrated in Figure-5, it demonstrats that the number of femtocell handover occurred was higher than the proposed method. This was caused by the proposed method being able to reduce the number of handover and interference in LTE HetNets. Minimize the interference means that the capacity will be also increased.

B) The Effect on number femtocell deployed with the number of macrocell handover for 100 UE (High speed)

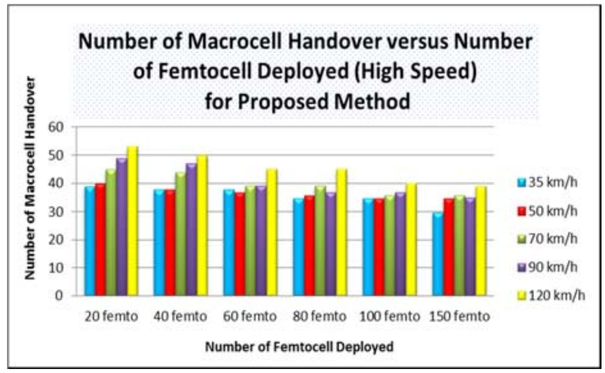

Figure-6. Number of macrocell handover vs number of femtocell deployed (Proposed method for high speed).

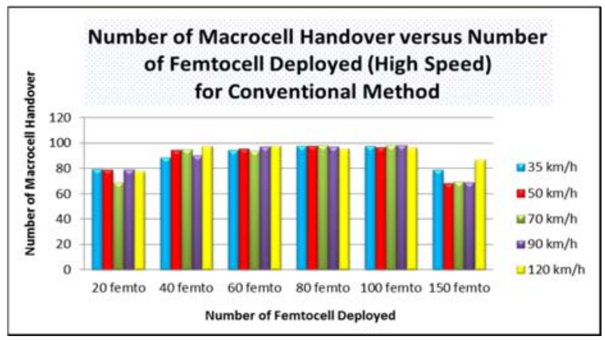

Figure-7. Number of macrocell handover vs number of femtocell deployed (Conventional method for high speed).

The number of macrocell handover for the number of femtocell deployed varied for the proposed and conventional method was discussed in Figure-6 and Figure-7 respectively. This analysis was run for 100 UEs and difference to the previous analysis which this analysis was done for the high speed of UE. The high speeds of UE were evaluated for 35 km/h, 50 km/h, 70 km/h, 90 km/h and also 120 km/h correspondingly. As seen in Figure 6 and Figure-7, the greater numbers of macrocell handover were happened when there is an increasing speed of the UE in the network. Meanwhile, as the number of femtocell positioned in the LTE HetNets enlarged, it lead to reduction of number of macrocell handovers. The number of handovers for the proposed method was reduced as compared to the conventional method. This is because when the interference can be reduced, the system capacity will be increased as well.

C) The effect on number of UE with the number of handover for low speed

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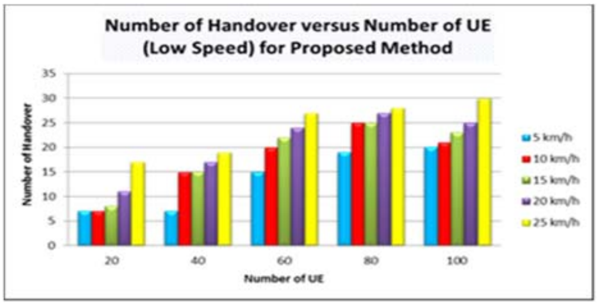

Figure-8. Number of handover vs number of UE (Proposed method for low speed).

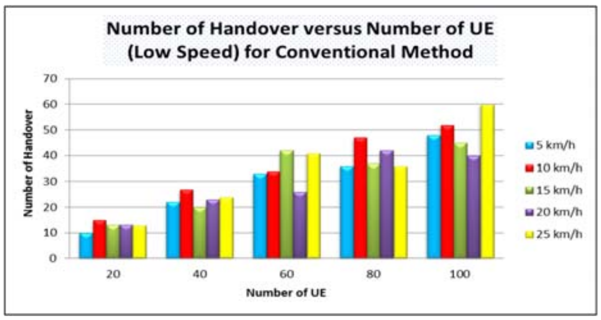

Figure-9. Number of handover vs number of UE (Conventional method for low speed).

Figure-8 and Figure-9 demonstrate the number of handover initiated versus the number of UE for low speed UE for the proposed and conventional method, respectively. There were five different speeds which were from 5 km/h, 10 km/h, 15 km/h, 20 km/h and 25 km/h as well as the number of UEs varied among 20 UEs and 100 UEs with the purpose of perceive and analyze the number of handovers initiated at low speed of UEs. As we can see in both Figures 8 and 9, the number of handover initiated increased once the setting of speed increased from 20 UEs to 100 of UEs. It also display that the proposed method better in terms of lessen the number of handovers initiated as compared to the conventional method. The proposed method result supported the main point of this research study which was to minimize the interference and improve the system network. From the outcome reached, when the number of handovers reduced, it could also increase the system capacity and hence the interference can be reduced in the network.

D) The effect on number of UE with the number of handover for high speed

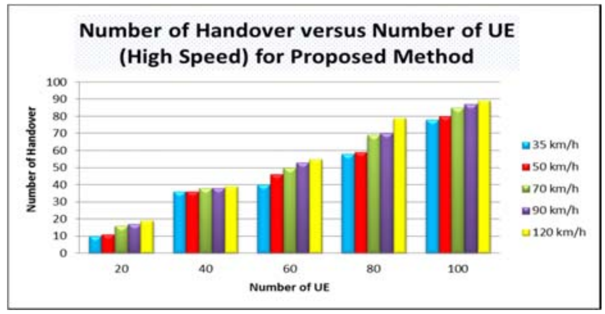

Figure-10. Number of handover vs number of UE (Proposed method for high speed).

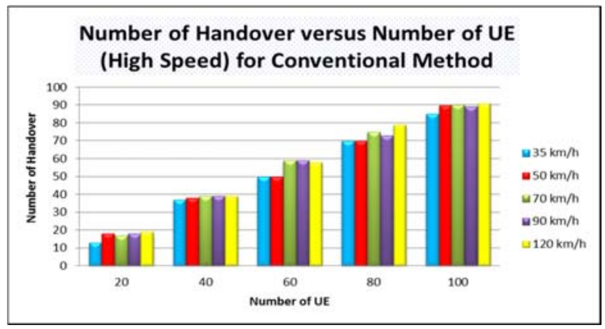

Figure-11. Number of handover vs number of UE (Conventional method for high speed).

The number of handover when the number of UE varied for the proposed and conventional method were showed respectively in Figure 10 and Figure-11. The high speeds of UE were evaluated for 35 km/h, 50 km/h, 70 km/h, 90 km/h and also 120 km/h. According to Figure-10 and Figure-11, as the UE speed in the network increases, the higher the number of handover occurred. Meanwhile, as the number of UEs in the LTE HetNets increased, the number of handover increased as well. From the results achieved in both Figures 10 and 11, it showed that the proposed method was enhanced as compared to the conventional method in terms of minimizing the number of handovers occurred in the HetNets.

E) The effect on speed with the number of handover

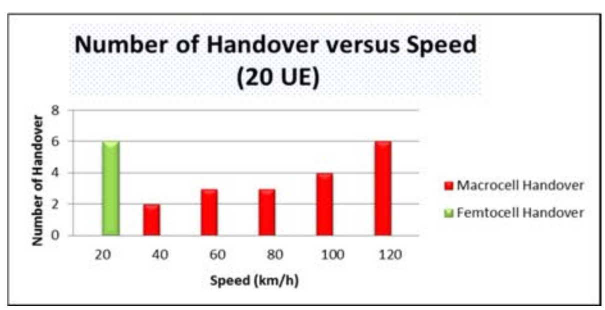

Figure-12. Number of handover vs speed (20 UE).

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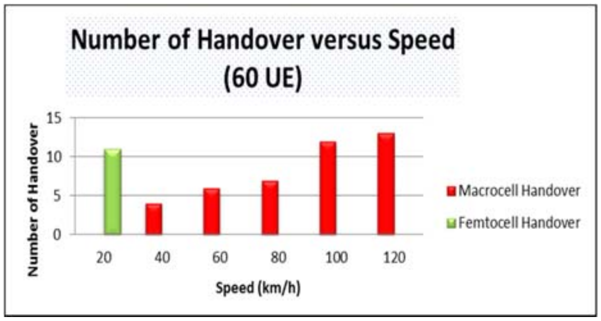

Figure-13. Number of handover vs speed (60 UE).

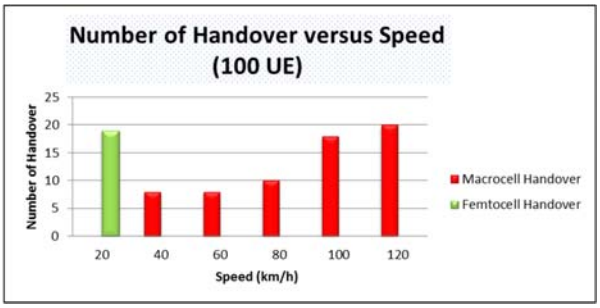

Figure-14. Number of handover vs speed (100 UE).

Figure-12, Figure-13 and Figure-14 discuss the evaluation between the macrocell and femtocell handover occurred for the varied UE speed from 20 km/h, 40 km/h, 60 km/h, 80 km/h, 100 km/h and also 120 km/h for 20 UEs, 60 UEs and 100 UEs, respectively. It can be seen in Figure 12 to Figure-14 that when the UE speed was below 30 km/h, only the femtocell handover occurred whereas the macrocell handover allowed when high speed UE above 30 km/h. Besides that, the higher the number of UEs in the network, the increase the number of handover occurred. The number of handover indicated that the UE successfully connected to the nearest BS as it moves out from one cell to another. One significant point to state here is that as the number of handover is higher, the UE capacity increased and this can reduce on network overload. However, this difficult can be overcome with the proposed method in this research where the interference was minimized and the difficult of the dropping calls can be disallowed.

CONCLUSIONS

This paper focuses on the combining of the interference management methods for macrocell and femtocell LTE network which were the FFR and DPC methods. The aim of this study is to lessen the interference in macrocell and femtocell network hence increases the network performance by offloading the macrocell traffic to the femtocell network based on the proposed methods. Through the handover performance by using the FFR and DPC methods, the analysis was compared with the proposed methods and the conventional method. For this handover performance, there were five differents analysis has been done where the analysis was divided into two categories of speed which were low and high speeds. From the simulation results achieved, it shows that when the number of handovers reduced, it could also increase the system capacity and hence the interference can be reduced in the network. Therefore, it proved that by combining the FFR and DPC methods in LTE HetNets, the handover were reduced, the interference can be minimized and hence increasing the system capacity.

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