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SINR PERFORMANCE BY COMBINING FRACTIONAL FREQUENCY REUSE AND DYNAMIC POWER CONTROL METHODS BASED ON SIMULATION MODEL

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ABSTRACT

In order to cope with the increase in demand for stable and high data rates among mobile users, femtocell or called as Home Evolve Node B (HeNB) has been developed to improve indoor capacity and coverage. Femtocell is a small base station aims for indoor usage such as at home or enterprise. The femtocell transmits a cellular signal that is received by mobile users then backhauled through the user's wired broadband connection. 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. This paper analyzed the interference management which are combining of Fractional Frequency Reuse (FFR) and Dynamic Power Control (DPC) methods by looking on the Signal to Interference plus Noise Ratio (SINR) performance based on the proposed fraction of cell radius (rth), fraction of system bandwidth (β) and path loss compensation factor (α) value in our previous papers. The proposed rth, β and α are then used in the simulation model in order to analyzed the SINR performance between the proposed method and the conventional method. The simulation results showed that the proposed method gives the higher values of SINR and show that there is a significant reducing of interference occurrence compared to the conventional method.

Keywords: home evolve node B, fractional frequency reuse, dynamic power control, signal to interference plus noise ratio, interference.

1. INTRODUCTION

Long Term Evolution (LTE) is a high speed wireless data communications technology for mobile phones and data terminals based on the Global System for Mobile Communications/Enhanced Data Rates for GSM Evolution (GSM/EDGE) and Universal Mobile Telephone System/High Speed Packet Access (UMTS/HSPA) network technologies. LTE is the Fourth Generation (4G) solution proposed by the 3G Partnership Project (3GPP) that intended to increase the data rates at about 10 times higher than what is possible on current UMTS-based systems for about more than 100 Mbps on the downlink, and more than 50 Mbps on the uplink.

Femtocell is proposed in the IEEE 802.16m SDD technical document (IEEE 802.16) in order to reduce macrocell coverage holes and to improve indoor transmission quality. Femtocell Base Station (FBS) is a low power and user deployed wireless access base stations. FBS is connected to the core network by using cable, Digital Subscriber Line (DSL), optical cable or similar backhaul technology (IEEE 802.16m.2009). Femtocells utilize licensed frequency band and lower transmission power compared to macrocells. Moreover, femtocells are not required to provide large storage capacity to save user data, thus make it suitable for wide deployment since they are simple, low cost, and easy to install (Kang *et al* 2011) as shown in Figure-1. However, by deploying femtocells in real environments, interference between macrocells and femtocells become a major problem since the interference seriously affects the performance of both macrocell and femtocell (Bum *etal*2011). Standard of LTE Femtocells has been discussed in the (Femto Forum 2011) and 3GPP (releases 2007,2008,2009,2010).

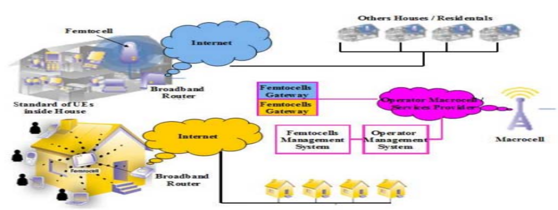

Figure-1. Typical femtocells deployment scenario (Azita *et al* 2013).

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 *etal* 2010) (Thomas *et al* 2010) and through the power control (Marceau *et al* 2011). Power control plays an important role on the uplink of LTE cellular network.

The standard has defined a combination of open loop and closed loop power control, where open loop power control is often called as Fractional Power Control (FPC) because it allows User Equipment (UE) to partially compensate the path loss (Marceau *et al* 2011). FPC is characterized by few parameters, and one of it is the path loss compensation factor (α) in which α is used to determine the better RSS and SINR values.

The rest of this paper is organized as follows. Section II presents an overview of the related works. Section III introduces the methodology of the interference

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management by using the proposed methods. The performance evaluations are carried out to analyze the performance of the SINR for both macrocell and femtocell networks in Section IV. Finally, conclusions are drawn in Section V.

2. RELATED WORK

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. Refer to technical paper (Kanak *etal.* 2013) "Comparison of SINR in femtocell and macrocell network in macrocell environment" written by Kanak Raj Chaudhary and Rachna Arya, the paper evaluates the SINR performance of femtocells in presence of macrocell. In this study, the author minimizes the interference between macro and femto in order to improve the performance. Besides, the author also analyzes the outage probability in femtocell network. Finally, consider the power consumption of femtocell network. The simulation results have presented an optimumcombination of ranges for lowest interference for femtocellusers. In the finding, we had seen that deployment of femtocell reduces the powerconsumption and improve the coverage. However, this technique need to deploy efficiency first then the performance in term of power and coverage can be improves later.

The authors of (Philippe *et al.* 2008) studied the different frequency reuse schemes in Orthogonal Frequency Divison M Access (OFDMA) network such as the LTE in order to prevail over the Co-Channel Interference (CCI) problem. The total frequency band is separated into several sub-bands and each cell is allocated with the dissimilar sub-band as the way to lessen the interferences. The authors have presented expressions of SINR as well as cell data rate for integer frequency reuse (IFR), FFR and two level power control (TLPC) schemes where is offered an analytical approach based on the fluid model. The conclusion of this authors work is intra-cell interference is removed and the inter-cell interference is significantly reduced.

The author of (Aleksandar *et al.* 2015), investigated a coverage radius based adaptive power control scheme to mitigate interference for blindly placed LTE femtocells. The author was analyzed by using system level simulation where is for single and multi-cell scenario. The simulation results have shown that the proposed scheme has an improved value of cross-tier SINR, throughput and lower co-tier SINR while compared to baseline and existing adaptive interference mitigation schemes. However, the proposed scheme does not require FAPs to be relocated on optimal locations for effective interference mitigation.

In (Reben *et al.* 2015), a femtocell power adjustment method whose main objective is to surge the average throughput of non-CSG MUEs by preventive the amount of interference caused by femtocells is proposed. However, the proposed priority weights used in the femtocells' Score Functions provide an efficient means for achieving the desired level of macrocell/femtocell throughput trade-off.

In (Dimitrious *et al.* 2012), a method for optimal FFR scheme selection based on the mean user throughput or user satisfaction is proposed. This lesson is shown in a cellular network that does not bring the presence of femtocells. In (Shahadate *et al.* 2014), instant channel allocation technique is proposed under FFR method in order to improve the system throughput. In this research work, the Physical Resource Blocks (PRBs) is allocated to femtocells user through sectored FFR method to mitigate the interference between macrocell and femtocell. However, this research work only adopted three sectored FFR to analyze the performance of the implemented scheduling algorithms.

In (Shah *et al.* 2014), FFR based resource allocation for device to device (D2D) is proposed. D2D communication consents two cellular devices to connect with each other without a base station. Another research work regarding on D2D communication in cellular networks with adopted the FFR method to mitigate interference is proposed in (Huiling *et al.* 2014). However, this research work also adopted three sectored of FFR same applied in (Shah *et al.* 2014).As we can see from the previous researcher's work, they were mostly focused on one method of the interference management in order to improve the performance in LTE network. Hence, this study looking forward to study the intereference management in macrocell and femtocell LTE network by combining the two interference methods which are the FFR and the DPC methods.

Motivated by the accomplishment by (Chang *et al* 2011), (Akindele *et al.* 2012), (Zainul. 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 in term of SINR performance of the user's by applying into simulation model. By simulation model developed, the performance of SINR will be analyzed with comparing it performance between the proposed method and the conventional method.

3. METHODOLOGY

This paper focuses on reducing the interference through interference management based on the FFR and DPC methods. Firstly, the SINR performance of macrocell and femtocell were analyzed by comparing it with the proposed methods and the conventional method. Then, followed by the deployments of a handoff algorithm for macrocell and femtocell in LTE network.

The scenario algorithm was proposed in this paper by using MATLAB software. The program was designed and modified to model a cellular network. The parameters of the simulation model were set as listed in Table-1. Under simulation model, we assumed 100 numbers of UE where distributed uniformly with setting into two different type of speeds which are the low speed and the high speed.

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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

4. PERFORMANCE EVALUATION

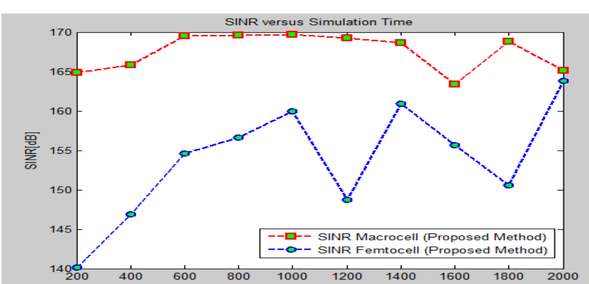

Figure-2. The correlation between macrocell and femtocellsinr with simulation time.

Figure-2 evaluates the correlation between the SINR with simulation times for both network which are the macrocell and femtocell networks. The SINR performance for the macrocell and femtocell were simulated using one user in order to observe the performance of the SINR achieve by the user at a time which were varied from 200 up to 2000 second(s). As can be seen in Figure-2, the performance of the SINR macrocell was higher than the SINR femtocell. In this evaluation, the DPC method was applied into the femtocell since the performance of the SINR femtocell using the FFR method only had not enhanced.

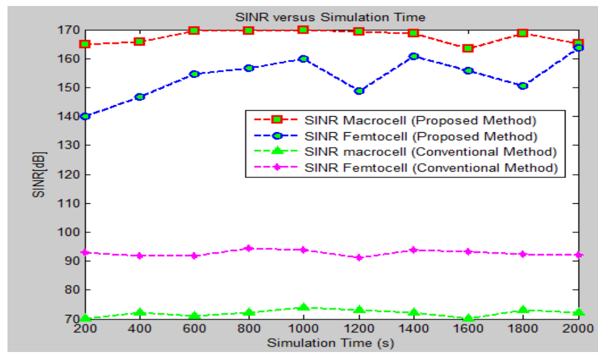

Figure-3. The differentiation between SINR proposed and conventional method.

Figure-3 presents the differentiation between the proposed SINR and conventional method for both macrocell and femtocell. From this analysis, it can be said that the graph demonstrated that the SINR performance for both macrocell and femtocell proposed method was enhanced than the SINR of conventional method. This occurred because the proposed method was applied on the FFR and DPC in order to reduce the inter-cell interference. The UEs will achieve the suitable SINR and hence the network performance will also be improved once the interference for both macrocell and femtocell were reduced. Therefore, it showed that the proposed method of combining the FFR with DPC methods can increase the user SINR, lessen the interference and therefore balancing the user in the network.

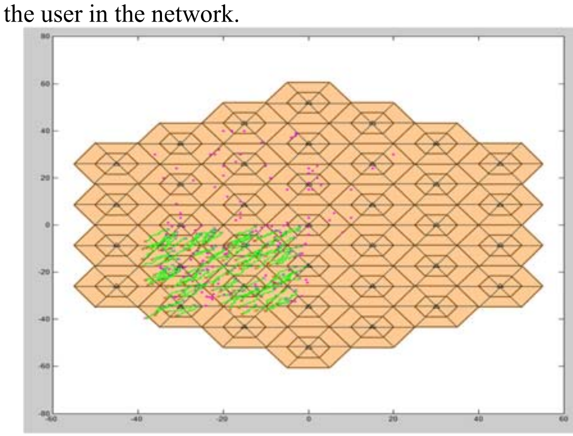

Figure-4. The effect on number of handover for the random ue movement and ue random position.

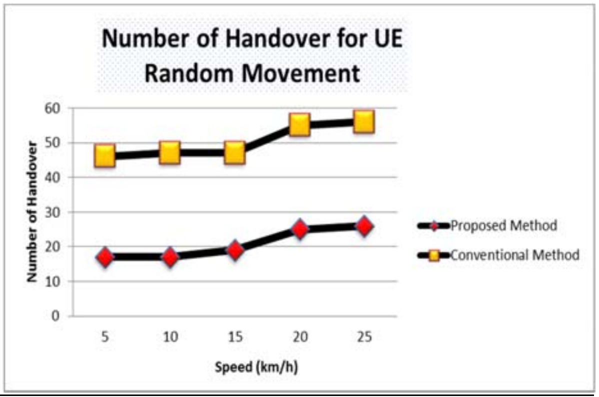

Figure-5. Number of handover versus speed for random ue movement and ue random position.

Figure-4 shows the deployment model for the random UE movement and UE in random position. Figure-5 showed the number of handovers calculated by two different methods that is the proposed method and the conventional method as for 100 UE's. From the graph illustrated in Figure-5, the graph shows that the number of handover for the proposed method was reduced compared to the conventional method.This simulation was completed for the lower UE speeds which are 5 km/h, 10 km/h, 15 km/h, 20 km/h and 25 km/h with the aim of analyze the effect of the Femtocell Base Station (FBS) on the number the of handover occurred. It was caused by the proposed method which combined the FFR and DPC methods that can lessen the interference in LTE HetNets. It can be seen that the handovers were reduced when the interference can be minimized. As a result of this, the system capacity will be improved.

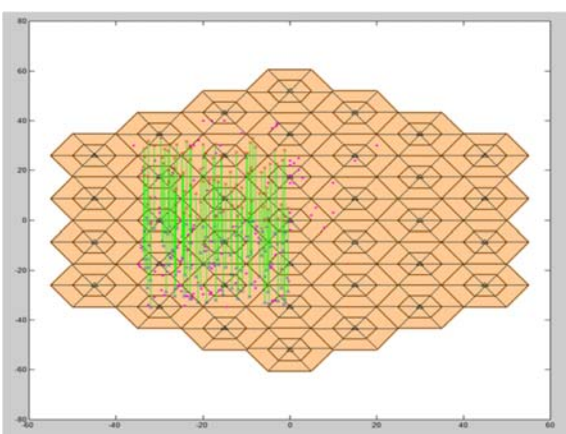

Figure-6. The effect on number of handover for the straight ue movement and ue random position.

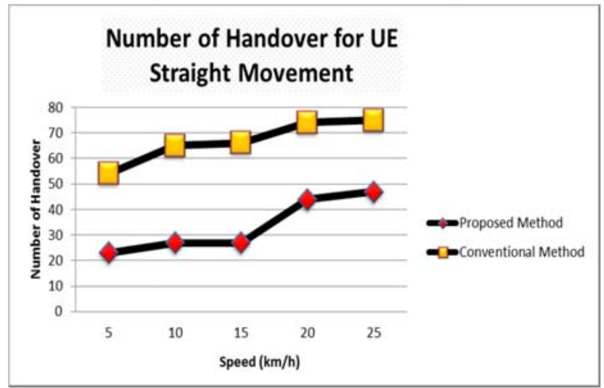

Figure-7. Number of handover versus speed for straight ue movement and ue random position.

Figure-6 presents the deployment model for the straight UE movement and UE in random position while the number of handovers calculated based on the proposed and the conventional methods for 100 UE show in Figure-7. According to Figure-7, it can realize that the number of handover for the conventional method was greater as related to the proposed method. As stated earlier, the proposed method reduced the number of handover since the FFR and DPC methods proposed in this research study. As a outcome of this, the handovers were reduced. Besides that, after equated to the outcomes of the number of handovers occurred for random and straight UE movement individually, it presented that the number of handover for the straight UE movement was higher as compared to the random UE movements. This is because when UE was in a straight movement, it may attach to added FBS as compared to the random UE movement which was fewer FBS for UE to attach. Hence, based on the number of handover outcome in Figure-5 and Figure-7, the movement and position of UE was affecting the number of handovers occurred.

5. CONCLUSIONS

This paper focuses on the interference management method for macrocell and femtocell LTE networks. In this study, the FFR method was combined with the DPC method in order to lessen the interference in macrocell and femtocell network hence increases the network performance in term of the SINR user performance. The influencing factor such as fraction of cell radius (rth), fraction of system bandwidth (β) and path loss compensation factor (α) value has been proposed in the previous papers and then used in the simulation model in order to analyze the SINR performance in this paper. Through the SINR performance, the analysis was compared with the proposed combining methods and the conventional method. After that, the performance of handoff that used the proposed combining methods which FFR and DPC methods was analyzed. For this handoff performance, the effect on number of handover for the random and straight UE movement has been done. It showed that the number of handover for the straight UE movement was higher as compared to the random UE movements. This is because when UE was in a straight movement, it may connect to more FBS as compared to the random UE movement which was less FBS for UE to connect. As known, FFR and DPC are the interference mitigation methods that can be applied into the LTE HetNets in order to reduce the interference occurring which therefore increases the system capacity of the network. By applying these two proposed methods in this research studies, the handovers were reduced, hence increasing the system capacity and reduced interference.

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REFERENCES

IEEE 802.16 Broadband Wireless Access Working Group, IEEE 802.16m System Description Document,' IEEE 802.16m-08/003r1, 2009-02-07.

Kang J.T., Sung C.S. and Ting C.H. 2011. Location-dependent power setting for next generation femtocell base stations, in Proc. IEEE Wireless Communication and Networking Conference (WCNC), pp. 767-772.

IEEE 802.16m-08/004r5. IEEE 802.16m Evaluation Methodology Document (EMD). 2009-01-15.

Bum G.C., Eun S.C., Kyung Y.C., Min.Y.C., and Ae S. P. 2011. A femtocell power control scheme to mitigate interference using listening TDD frame, In: Proc. IEEE International Conference on Information Networking, Barcelona. pp. 241-244.

F. Forum, Regulatory Aspects of Femtocell, 2nd ed., Femto Forum, March 2011.

3rd Generation Partnership Project, Technical Specification Group Services and System Aspect; Telecommunication Management; UTRAN and GERAN Key Performance Indicators (KPI) (Release 7), 2007.

3rd Generation Partnership Project, Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2 (Release 8), 2009.

3rd Generation Partnership Project, Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); TDD Home eNode B (HeNB) Radio Frequency (RF) requirements analysis (Release 10), 2010.

3GPP TSG RAN WG4 (Radio) Meeting; Technical Report Approval R4-092042: Simulation Assumption and Parameters for FDD HeNB RF Requirements. #51 San Francisco, CA, 4-8 May2009.

Azita L.Y., Siti S.S., Norsuzila Y. and Mohd.T.A. 2013. Performance Analysis of Handover Strategy in Femtocell Network, in Journal of Communication. Vol.8, No.11.

Vikram C., Jeffrey A., Tarik M., Zukang S. and Alan G. 2009. Power Control in Two-Tier Femtocell Network, IEEE Trans. Wireless Commun. 8.

Heui C.L., Dong C.O. and Yong H.L. 2010. Mitigation of Inter-Femtocell Interference with Adaptive Fractional Frequency Reuse, in Proc. of ICC 2010 IEEE, Cape Town.

Thomas N., Jeffrey G.A., Illsoo S., Radha K.G. 2010. Comparison of Fractional Frequency Reuse Approaches in The OFDMA cellular downlink, in Proc. of GLOBECOM, IEEE, Miami.

Marceau C. and Jean M.K.2011. How to Set the Fractional Power Control Compensation Factor in LTE, IEEE.

Kanak R.C. and Rachna A.2013. Comparison of SINR in FemtoCell and MacroCell Network in MacroCell Environment. International Journal Of Engineering And Computer Science ISSN:2319-7242, 2(8): 2476-2480.

Philippe.G., Masood M., Marceau.C. and Jean M.K. 2008. Analytical Evaluation of Various Frequency Reuse Schemes in Cellular OFDMA Network. ValueTools.

Aleksandar I., Vladimir A. and Liljana G. 2015.Hybrid access control with modified SINR association for future heterogeneous networks. IEEE GLOBECOM Workshop on 5G Heterogeneous and Small Cell Network.

Reben K., Lila B. and Megumi K. 2015. Femtocell power control methods based on users' context information in two-tier heterogeneous networks. Kurda *et al.* EURASIP Journal on Wireless Communications and Networking, 2015:129DOI 10.1186/s13638-015-0328-z.

Dimitrios.B., Christos B., Vasileous K., Andreas P. and Georgea T.S .2012. Optimization of Fractional Frequency Reuse in Long Term Evolution Network. WCNC.

Shahadate R., Shahedur R., Aboubaker L. and Jonathan L. 2014. Instant Channel Allocation Technique to Improve System Throughput in Joint LTE Cellular Network. 28th International Conference on Advanced Information Networking and Application Workshops, doi 10.1109.

Syed T.S., Jaheon G., Min Y.C. and Syed F.H. 2014. FFR based Resource Allocation Scheme for Device-to-Device Communication. IEEE 3rd Global Conference on Consumer Electronics (GCCE), 978-1-4799-05145-1.

Huiling Z. and Jiangzhou W. 2014. Device-to-Device Communication in Cellular Networks with Fractional

ARPN Journal of Engineering and Applied Sciences

Frequency Reuse. IEEE ICC Wireless Communications Symposium, 978-1-4799-2003-7.

Chang Y.O., Min.Y.C, Hyunseong C. and Tae J.L. 2011. Resource Allocation with Partitioning Criterion for Macro-Femto Overlay Cellular Networks with Fractional Frequency Reuse. Wireless Pers Communication.

Akindele S.A. 2012. Inter-Cell Coordination for Interference Mitigation in Multi-Tier Wireless Networks. Kobe University Repository : Thesis, vol. 993.

Zainul H.A.H. 2013. An Adaptive Power Control Mechanism for Femtocell LTE Network. University Technology Mara (UiTM) Shah Alam, Malaysia.