[PONVADIVU, 6(5): May 2019]
DOI- 10.5281/zenodo.3174613

ISSN 2348 – 8034
Impact Factor- 5.070

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

ADAPTIVE TRANSMIT POWER CONTROL FOR INTERFERENCE MITIGATION IN LONG-TERM EVOLUTION FEMTOCELL NETWORKS

M. PONVADIVU
Guest Lecturer, Department of Computer Science, Raja Doraisingam Govt. Arts college - Sivagangai

ABSTRACT

Heterogeneous networking of femtocells over the existing macro cell network is believed to augment the data rate requirement in forthcoming years. Closed access operation of Femtocell Access Points and shared spectrum assignment in the two-tier macro-femtocell network leads to unacceptable deterioration in achieved data rate of femtocell users. In this work, application of computationally efficient neural network to perform adaptive transmit power control of femtocell access point is proposed to improve the Quality of Service perceived by femtocell users. A Neuro-controller is designed to regulate the femtocell access point transmission power based on the Channel Quality Indicator measurement report sent by user equipment. Since the proposed power control strategy employs the channel side information already available in the existing network, there would not be any signaling overhead to mitigate the co-tier interference. Simulation results validate the effectiveness of the proposed power control strategy which provides significant improvement in achieved data rate of femtocell users and prevents them from outage.

Keywords *- Femtocells, LTE, Co-channel deployment, Interference, Power control.*

I. INTRODUCTION

Heterogeneous network (HetNet), in which installation of miniaturized low power short range, plug and play type cellular base stations known as Femtocell Access Points (FAPs) or Femtocell Base Stations (FBSs), is a promising and economical solution to cater for augmenting the data rate particularly at indoors [1]. FAPs denoted as Home eNode Base station (HeNB) in the Third Generation Partnership project (3GPP) terminology, are overlaid on the existing macrocells and connected to the mobile operator's core network via a wired / wireless Internet Protocol (IP) backhaul [2]. There exist many challenges for successful implementation of FAPs massively in urban and suburban areas and interference management of two-tier macrocell femtocell network is a prime issue that needs addressing to reap the benefits of femtocell technology. There is a lack of sufficient coordination between macrocell base station (MBS) and FAPs mainly due to issues related scalability, security and limited availability of backhaul bandwidth. Additionally, due to the mode of operation and ad hoc deployment nature of FAPs, interference management in such networks faces many practical challenges. In this work we have considered the cotier interference, where the provoker (e.g. an FAP) and the victim (e.g. a nearby FAP's user) belong to the same tier [3].

As LTE wireless networks are being designed to improve spectral efficiency and high date rate, LTE based femtocells are expected to gain more market in near future and the same are considered in this work. The main contribution of this work is an adaptive transmits power control strategy, which is not related directly or indirectly to the existing methods discussed above. Initially, Signal-to-Interference-plus-Noise Ratio (SINR) of femtocell users in the heterogeneous network environment are modeled and Channel Quality Indicator (CQI) based adaptive transmit power control is implemented using neural networks [4]. The performance of the proposedmethod is validated by estimating the achieved data rate of femtocell users with respect to the distance between them and their serving base station. The proposed neural network based adaptive FAP transmit power control method can be implemented with available local information only and hence there would not be any signaling overhead.

II. REVIEW OF LITERATURE

In this work, downlink communication in the two-tier LTE-based femtocell network that consists of FAPs overlaid on a single macrocell with Macrocell Base Station (MBS) located at the centre of the coverage region, providing a cellular coverage radius ***Rm*** is considered [5]. Each FAP has coverage radius ***Rf***, serves at least one active user and

ISSN 2348 – 8034
Impact Factor- 5.070

there are Nm active macrocell users. Therefore, totally $Nu=Nm+Nf$ users exist in the two-tier network considered here.

Let $M=\{m1,m2,\ldots,mi,\ldots,mNm\}$ represents the set of macrocell user equipments (MUEs), $F=\{F1, F2,\ldots, Fi,\ldots,FNF\}$ represents the set of FAPs overlaid on the macrocell considered and $Fu=\{f1,f2,\ldots fi,\ldots fNF\}$ represents the set of femtocell user equipments (FUEs), each one of them served by their corresponding FAPs. Hence the whole UE set considered here is $U=M\cup Fu$. FAPs are preferably located at the cell edge of MBS to provide better indoor signal to the users and it is assumed that all FAPs, whose coverage overlap and are operating in closed access mode, restricting unauthorized users to get connected with any particular FAP.

Since LTE based femtocell network is considered, the total system bandwidth B is divided into Nsc number of subcarrier, which are grouped into N subchannels (SCs) for multi-carrier transmission of information [6]. Each SC has Δf sub carrier spacing frequency. The set of orthogonal SCs assigned by base stations to their associated users depends on availability of spectrum. The more SCs a user assigned, and the higher the modulation and coding scheme used in the subcarriers, the higher the achieved data rate. Any particular SC and number of SCs the users assigned at a given point of time depend on the scheduling mechanism used. The following figure represents the Illustration of Downlink Cross-tier interferences scenario B in femtocell networks.

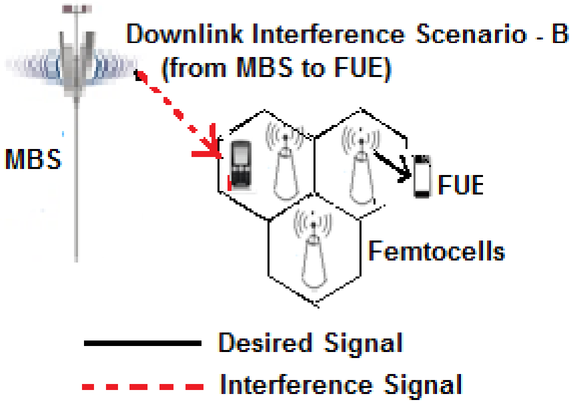

Figure 1. Illustration of Downlink Cross-tier interference scenario B in femtocell networks

Here it is assumed the each user is assigned with at least one SC and a proportional fair scheduler is used to assign SCs to users depending upon their minimum data rate requirement $Rmin$. Due to sharing SCs between the macrocell and femtocell tier, there is a greater chance for assignment of same SC to multiple UEs in nearby femtocells, at any particular instant of time. Due to this, co-tier interference may arise and the Quality of Service (QoS) perceived by the femtocell users, particularly at cell edge may be deteriorated. With an assignment of a same SC n by MBS and FAPs to MUE and FUEs respectively, the transmission from MBS cause crosstier interference on FUE (marked as B in Fig. 1). Apart from this, under the massive deployment of FAPs in sub-urban environment, there is overlap in coverage of nearby FAPs. This kind of co-tier interference greatly influence the performance observed by users in terms of poor data rate [7].

III. ADAPTIVE TRANSMIT POWER CONTROL STRATEGY

In LTE networks, based on the downlink reference signal measurement, UE estimates the Channel Quality Indicator (CQI) and sends it as a feedback to the MBS as an indication of data rate which can be supported by the downlink channel. Depends upon the CQI the MBS may select MCS and transport block size for the next sub-frame transmission. CQI is computed such that the transport block error rate will not exceed 10% [8]. Moreover, CQI is not just corresponds to the SINR the UE experiencing, it is the function of the ratio of the interference of the own base station compared with others. When the UE is close to the base station, a high CQI value is reported and respectively it is understood that low CQI reporting by the UE indicates that it is close to the cell edge, most of the interference comes from the nearby cells. In this work, to perform adaptive FAP transmit power control, which can be considered as a downlink power control problem, a Neuro-controller is designed. In LTE, measurement of Reference Signal Received Power (RSRP), Received Signal Strength Indicator (RSSI) and Reference Signal Received Quality (RSRQ) that provides the signal strength metric, the cell-specific signal quality metric and total received wideband power respectively are available. They are utilized in addition to the CQI measurement report, which are fed as input to the Neuro-controller. The Neuro controller adjusts the FAP transmit power based on the CQI report received from UEs and performs subchannel power allocation accordingly to reduce the co-channel interference affected by user *i*, during the previous sub-frame transmission [9].

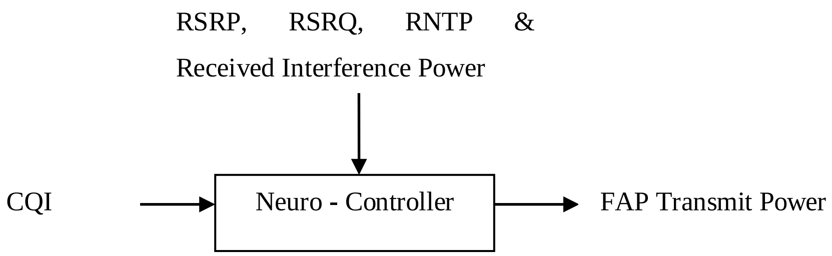

Figure 2. Block Diagram for Intelligent FAP Transmit Power Control

The proposed Neuro-controller is a feed-forward neural network (Multilayer Perceptron) which is trained using Quasi- Newton Backpropagation algorithm, which is an alternative of conjugate gradient method for fast optimization. Even though it requires more computation in each iteration and more storage, it generally converges in little iteration. Another very important parameter of neural network is the selection of the activation function [10]. Since the input neurons do not process any information identity function is chosen as the activation function. For function approximation, hyperbolic tangent is used as activation function of hidden neurons, while a linear activation function is used in the output. It should be remembered that any function may be approximated to an arbitrary degree using one hidden layer itself, but over fitting can occur if there are too many hidden units. The said neural network has an input layer, a single hidden layer and an output layer. CQI is fed as input to the Neuro-controller; whereas the adjusted FAP transmit power is the output of the same.

IV. RESULT & DISCUSSION

A HetNet system level simulation to analyze the performance of the proposed adaptive FAP transmit power control strategy is performed. Since LTE based femtocell network is considered in this work, simulation parameters relevant to LTE network are utilized and the same are listed in the following table.

Parameters	**Value**
Carrier Frequency	2 GHz
System Bandwidth	20 MHz
Number of subcarriers per RB	12
Number of RBs	100
Modulation	64 QAM
Target BER	10^6
FAP Transmit Power 100Mw	100mW

MBS Transmit power 20 W	20W
Penetration loss of outer wall	20 dB
Penetration loss of inner wall 5	5 dB
Noise PSD	-174 dBm
Number of Macrocell User	50

The HetNet scenario used in this work assumes the MBS deployed in the centre of the macrocell along with FAPs, macrocell users and femtocell users are randomly distributed. Initially, the SINR of the users are simulated for various interference scenarios discussed in section II and the same are used for estimating their achieved data rate with fixed ***Ptf*** and compared the same with the proposed Neuro-controller adjusted ***Ptf***. The achieved data rate of femtocell users with respect to the distance from their serving base station is evaluated. Additionally, the plots pertaining to the Neurocontroller adjusted ***Ptf*** is also presented. Fig.3 illustrates an improvement in the data rate of the femtocell user with Neurocontroller adjusted ***Ptf***, in the case of one and two interfering nearby FAPs, whereas Fig.4 explains the same in the case of three and four interfering FAPs. It is observed that with more number of interfering FAPs transmitting at fixed ***Ptf***, the cell edge user (at the distance above 20m) would accomplish very poor QoS due to data rate less than 0.5 Mbps. But, with Neuro-controller adjusted ***Ptf***, the data rate achieved is significantly improved and even the cell edge user can achieve 2.69Mbps.

V. CONCLUSION

In this work, downlink communication in the two-tier LTE-femtocell network is considered and a novel neural network based adaptive FAP transmission power control strategy is proposed. The performance of the proposed power control strategy is evaluated using system level simulation and compared with the fixed FAP transmission power. Under shared sub channel usage, the data rate achieved by the users with respect to the distance from their serving base station is simulated. The observation of deterioration in data rate with fixed FAP transmission power indicates the impact of interference and addresses the need for an efficient interference mitigation strategy for improving the QoS perceived by the users. The proposed FAP transmission power control method provides significant performance improvement in terms of achieved data rate at very low FAP transmission power. Additionally, the plot related to Neuro-controller adjusted FAP transmission power signifies the energy efficiency of the network considered.

REFERENCE

1. *Chandrasekhar, J. G. Andrews, and A. Gatherer, "Femtocell networks: a survey," IEEE Commun. Mag., vol. 46, no. 9, pp. 59–67, Sept. 2008.*
2. *D.L´opez-P´erez, A.Valcarce, G.De La Roche and J.Zhang, "OFDM femtocells: A Roadmap on Interference Avoidance," IEEE Commun. Magazine, vol. 47, no. 9, pp. 41–48, Sept. 2009.*
3. *Femtoforum, "Interference Management in OFDMA Femtocells," Whitepaper available at www.femtoforum.org, Mar. 2010.*
4. *Chandrasekhar, J. Andrews, T. Muharemovic, Z. Shen, and A. Gatherer, "Power control in two-tier femtocell networks," IEEE Trans on Wireless Commun., vol. 8, no. 8, pp. 4316–4328, Aug. 2009.*
5. *3GPP TR 36.921 version 9.0.0 Release 9, "LTE; E-UTRA; FDD Home Node B (HeNB) Radio Frequency Requirement Analysis," Mar. 2010.*
6. *Hae Beom Jung and Duk Kyung Kim, "Power Control of Femtocells Based on Max-Min Fairness in Heterogeneous Networks," IEEE Communication Letters, Vol.17, No.7, pp. 1372-1375, July 2013.*
7. *W. Yu and R. Lui, "Dual methods for nonconvex spectrum optimization of multicarrier systems," IEEE Trans. Commun., vol. 54, no. 7, pp. 1310–1322, July 2006.*
8. *Zhang, W. Zheng, X. Chu, X. Wen, M. Tao, A. Nallanathan, and D. Lopez-Perez, "Joint subchannel and power allocation in interference limited OFDMA femtocells with heterogeneous QoS guarantee," in Proc. 2012 IEEE Global Telecommun. Conf., pp. 4794–4799.*

9. *Sundeep Rangan and Ritesh Madan, "Belief Propagation Methods for Intercell Interference Coordination in Femtocell Networks," IEEE Journal on Selected Areas In Communications, Vol. 30, No. 3, pp. 631 - 640, April 2012.*
10. *Sungsoo Park, Woohyun Seo, Sooyong Choi and Daesik Hong, "A Beamforming Codebook Restriction for Cross-Tier Interference Coordination in Two-Tier Femtocell Networks," IEEE Trans. On Vehicular Technology, vol. 60, No. 4, pp. 1651-1663, May 2011.*