IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 5, Issue 1, January 2016

Green Network Design in Downlink MU-MIMO System Using Convex Optimization Technique

Chithra B Das

M.Tech scholar, Department of ECE, MZCE, Kadammanitta, Pathanamthitta, Kerala

Abstract: Wireless technology has become the primary enabler of mobility and ubiquitous network access over the past decade. Multiuser- MIMO (MU-MIMO) has emerged as one of the prime technologies for achieving spectral efficiency (SE) in 4G LTE- A system. In addition to spectral-efficiency improvement, energy efficiency (EE) is becoming increasingly important for wireless communications because of the slow progress of battery technology and the growing requirements of anytime and anywhere multimedia applications. But this two design criteria (SE and EE) conflict with each other and a careful study of their trade-off is necessary for green network planning in future wireless communication systems. By considering the SE requirement, as a constrained optimization problem where constraints redefined to maximize EE using convex optimization technique and it is done for a 2×2 antenna configuration. It is proposed to use 4×4 MIMO antenna configuration and also an optimal beam forming design for both 2×2and 4×4 configuration is considered.

Keywords: MU-MIMO, LTE-A, Beam forming, Green Network, Energy Efficiency.

I. INTRODUCTION

The next generation wireless networks are expected to provide high speed internet access anywhere and anytime. The popularity of smartphones doubtlessly accelerates the process and creates new traffic demand. Exponentially growing data traffic and the requirement of ubiquitous access have raised dramatic expansion of network infrastructures and fast escalation of energy demand. To meet the challenges raised by the high demand of wireless traffic and energy consumption, green evolution has become an urgent need for wireless networks today.
Among many features in the Long term Evolution Advanced (LTE-A), which supports 1Gb/s throughput in downlink and 500Mbps in the uplink, the multi-user multiple-input-multiple-output (MU-MIMO) scheme has been identified as one of the key enablers for achieving high spectral efficiency . From both the theory and design perspectives, MU-MIMO systems have several unique features distinct from single-user MIMO (SU-MIMO) systems. In SU-MIMO where the spatial multiplexing capability of a single user's channel is limited either due to signal-to-interference-plus-noise ratio (SINR), or fading correlations among antenna elements or by the number of receive antennas at the user side.

Once spectral efficiency was the performance metric of choice, now EE and the engineering trade-off between both metrics are also scrutinized to find an appropriate trade-off. The objective function is to design a green communication system by considering the trade-off relationship. Given the SE requirement and maximum power limit, a constrained optimization problem is formulated to maximize EE. The optimization problem where constraints are modeled as a cubic inequality and then a novel resource allocation algorithm to achieve maximum EE in a given SE. Both circuit and transmit power is considered while designing optimal EE systems. The optimization objective is to maximize EE while satisfying SE requirements. MU-MIMO networks are exposed to co-channel interference. In order to mitigate the effect of co-channel interference and improving the performances of the system Beamforming technique is also considered.

II. EXISTING SYSTEM

Green Communication design in MU-MIMO system with 2×2 antenna configuration in LTE network.

A. SYSTEM MODEL

The MU-MIMO system is illustrated in the fig.1 based on LTE technology.

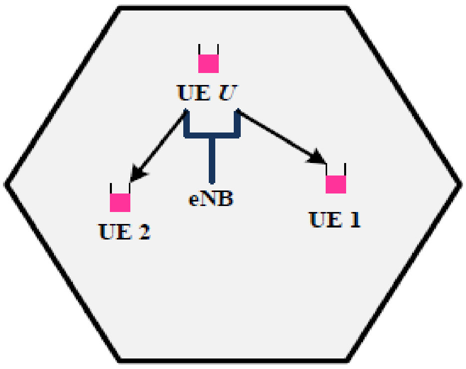


Fig. 1 MU-MIMO System: Hexagonal Cell Layout

For the single cell MU-MIMO system, interference is termed as intra-cell interference i.e. multiuser interference in the case of MU-MIMO. Intra-cell interferences are originated from the UEs of the same cells. To mitigate this interference, zero-forcing (ZF) precoding is considered, which transmits the signals towards the intended user's direction and nulls in the direction of other users, thus reducing intra-cell interference. Adaptive power allocation (according to the 3GPP LTE adaptive modulation & coding scheme using the channel condition among PRBs is considered and total transmit power $P(P = \sum_{u=1}^{U} p^{u} = \sum_{u=1}^{U}\sum_{m=1}^{M} p_u^m)$available on each HC is divided among the PRBs based on the channel condition of the UE. The main channel measurement considered is the Signal-to-Interference-plus- Noise-Ratio (SINR) of the UEs in the system. In order to determine whether a transmission has been successful, the SINR measured for a given path is employed to determine the packet error rate (PER) for the block of data sent on each PRB. The SINRΓ_u^m, perceived by a UE u on PRB mof theMU-MIMO cell can be expressed as

$$\Gamma_u^m = \frac{p_u^m \, |H_u^m W_u^m|^2}{\sum_{u' \neq u}^{U} p_{u'}^m \left|H_u^m W_{u'}^m\right|^2 + \sigma^2} \qquad (1)$$

where u$\in$ {1,2,…..U}:$H_u^m$is the complex channel matrix whose elements combine path loss, shadowing and fast fading and which models the link between the u^{th}UE and eNB of the cell c; $W_u^m$is the precodingmatrix for the link between the eNB and the UE u; and$\sigma^2$is the Additive White Gaussian Noise (AWGN) power as perceived by the UE. The intra-cell interference is mitigated using zero-forcing precoding design, taking the pseudo-inverse of channel matrix.

The total bandwidth B is equally divided into PRB, each with a bandwidth of W = B/M .Then, the spectral efficiency, SE, obtained by Shannon theorem, of user u on PRB m is

$$SE_u^m = \log_2|1 + \Gamma_u^m| \qquad (2)$$

Then, the maximum achievable data rate, S_u^{-m},of user u On PRB m is

$$S_u^{-m} = W.SE_u^m \qquad (3)$$

Let S_u^m, be the data rate for user uon PRB mat any instant. Overall system throughput S and total transmit power P=$\sum_{u=1}^{U}\sum_{m=1}^{M} p_u^m$, $S = \sum_{u=1}^{U}\sum_{m=1}^{M} s_u^m$,where p_u^m is the transmitted power of eNB for user u on PRB m. Transmission power also counts on the power amplifier

Efficiency, which is denoted as α where α € [0,1] and depends on the design and implementation of the transmitter. Apart from the transmission power we consider circuit power as well. From circuit energy consumption,$P_c$can be divided into a staticpart and a dynamic part that depend on parameters of active links. $P_c = P_{st} + \delta.S$, where $P_{st}$is the staticcircuit power in the transmit mode and δ is a constant denotingdynamic power consumption per unit data rate.

B. PROBLEM FORMULATION

For a downlink MU-MIMO LTE network, EE optimization problem can be formulated as

$$\max_s EE = \frac{\sum_{u=1}^{U}\sum_{m=1}^{M} s_u^m}{\frac{P}{\alpha} + P_{st} + \delta \sum_{u=1}^{U}\sum_{m=1}^{M} s_u^m} \qquad (4)$$

EE is defined as transmitted bits per unit energy consumption at the transmitter side, where the energy consumption includes transmission energy consumption and circuit energy consumption of transmitter. subject to constraint:

$$1. S_u{}^{m} \leq S_u^m \leq S_u^{-m}$$

$$2. \; S_u^m > 0$$

where $S_u^{\wedge m}$denotes the minimum rate requirement for user uon PRB m.

In order to ensure the convexity of the proposed optimization problem, constraint is redefined as a cubic inequality. The reformulated constraint based on non-negativity, is given as

$$1. (S_u^m).(S_u^m - S_u^{-m}).(S_u^{-m} - S_u^m) > 0$$

$$2. S_u^m > 0$$

C. CONVEX OPTIMIZAION TECHNIQE

EE is concave in SE and the solution space defined by the constraints is convex, so it's a convex optimization problem. Using standard optimization techniques, the Lagrangian of$L(S, \lambda)$ is (5)

$$EE + \sum_{u=1}^{U}\sum_{m=1}^{M} \lambda_u^m \; [(S_u^m).(S_u^m - S_u^{-m}).(S_u^{-m} - S_u^m)]$$

Where λ is the Lagrange multiplier.Next differentiating $L(S, \lambda)$ with respect to S_u^m and the feasible solution is given by

$$S_u^m \, (OPT) = D, S_u^{-m} \qquad (6)$$

$$D = \frac{\frac{P}{\alpha}+P_{st}}{(\frac{P}{\alpha}+P_{st}+\delta \sum_{u=1}^{U}\sum_{m=1}^{M} s_u^m)^2}+[-\lambda_u^m \left[3(S_u^m)^2 2S_u^m \left[S_u{}^{m} + \right.\right.$$

$$Sum \; Sum.Su{-}m \qquad (7)$$

Let $\Omega_u^m = \lambda_u^m$, the upper bound of the numerical search can be defined as, when $S_u^m = S_u^{-m}$

$$\Omega_{UB} \quad \frac{\frac{P}{\alpha}+P_{st}}{(\frac{P}{\alpha}+P_{st}+\delta \sum_{u=1}^{U}\sum_{m=1}^{M} s_u^m)^2}+[3(S_u^m)^2 - 2S_u^m \, [S_u^m +$$

$$Sum\,][Su{\wedge}m \,.Su{-}m \,]] \qquad (8)$$

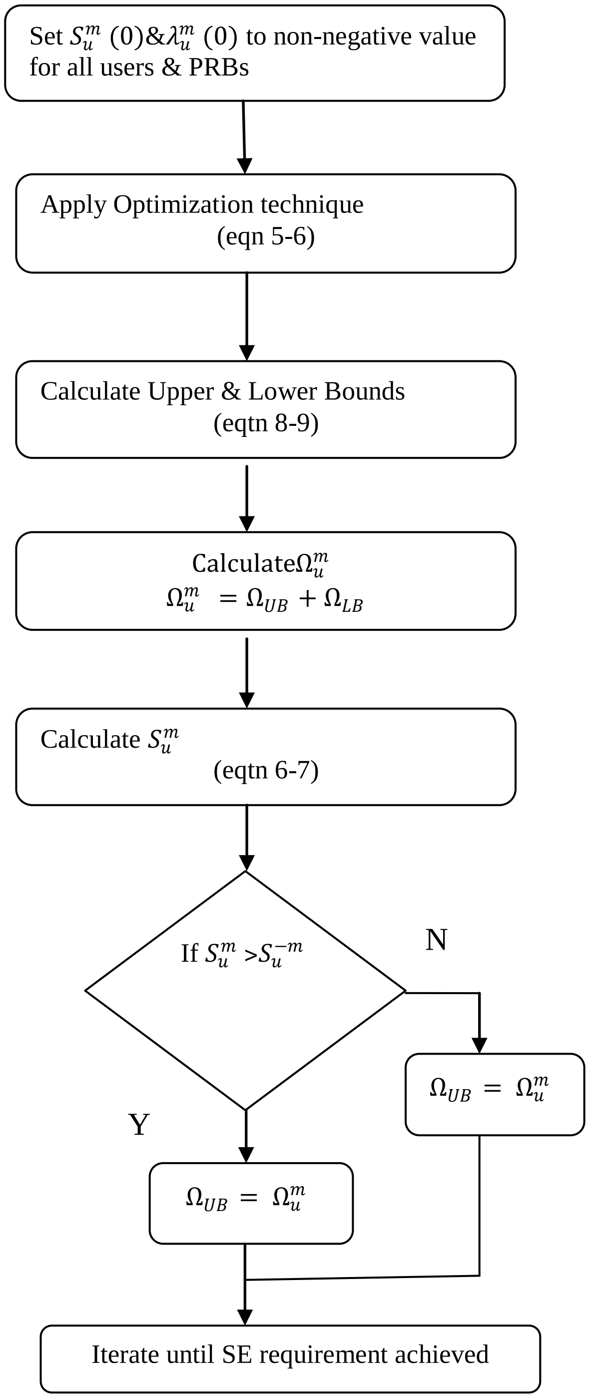
When $S_u^m = 0$, the lower bound of the numerical search can be defined as

$$\Omega_{LB} = \frac{\frac{P}{\alpha}+P_{st}}{(\frac{P}{\alpha}+P_{st})^2\{S_u^{\wedge m} \,.S_u^{-m}\}} \qquad (9)$$

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 5, Issue 1, January 2016

D. OPTIMAL POWER ALLOCATION ALGORITHM



III.PROPOSED SYSTEM

It is proposed to use 4×4 MIMO antenna configuration also along with Beamforming design is considered. Beamforming is a multi antenna technique that significantly reduces interference and improves system capacity. Beamforming is like a laser, which can deliver data directly to specific devices, while previous wireless is like a light bulb spreading light (data) in a set of area. A laser can focus its power, so it can reach farther. Similarly, beamforming technology provides wider coverage. Beamforming is one of several technologies, as well as smart antennas and MIMO, that is used boost the range and capacity by providing a better signal-to-noise (SNR) ratio.

A. OPTIMAL BEAM FORMING DESIGN

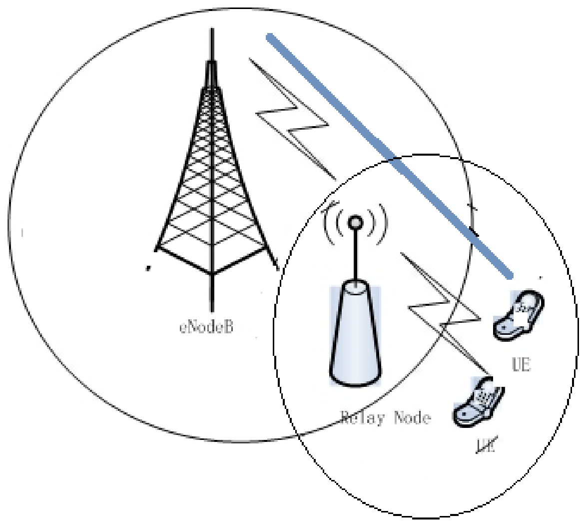


Fig. 3System Model for Beam forming design

The complex baseband received symbol at D in the source phase is mathematically given by

$$y_{D,S} = h_{D,S}^T + w_s x_s + n_{D,S} \qquad (10)$$

where$h_{D,S}^T$denotes the channel gain vector from S to D and $n_{D,S}$ is scalar additive Gaussian noise with unit variance.The signal to noise ratio (SNR) at eNB during the source phase is given by

$$\gamma_{D,S} = |h_{D,S}^T w_s|^2 p_s \qquad (11)$$

The baseband signal vector received at node R can be mathematically given by

$$y_{R,S} = H_{R,S} w_s x_s + n_{S,R} \qquad (12)$$

$H_{R,S}$where denotes the channel gain matrix from source S to relay R,$n_{S,R}$is the circular symmetry Gaussian noise vector with unit variance, i.e., Applying singular value decomposition (SVD).

It can be shown that the effective received SNR at R is

$$\gamma_{S,R} = ||H_{S,R} w_s||^2 p_s \qquad (13)$$

The optimal solution to the optimization problem is given by considering the mapping from $\gamma_{S,R}$ *to* $\gamma_{D,S}$.The co-ordinates of the point T and E is (x_T, y_T)and (x_E, y_E). When $y_E > x_E$and $y_T < y_E$, the optimal solution of Problem is

$$\alpha_1 = 2AB \pm \sqrt{1} - 4ABp_s - 4B^2$$
$$\propto_2 = 1 - \alpha_1 \qquad ; \alpha_1, \alpha_2 \geq 0$$
$$A = \lambda_1^2 - \lambda_2^2 - \beta_1^2 - \beta_2^2$$
$$B = \lambda_2^2 P_S - \beta_2^2 P_S - \gamma_{D,S} (14)$$

Where $\alpha_i = |{w_i}^2|$ *and* λ_1, λ_2 are the singular values and $\beta_i = |h_{D,S}^T| v_i$.

IJARCCE
ISSN (Online) 2278-1021
ISSN (Print) 2319 5940
International Journal of Advanced Research in Computer and Communication Engineering
Vol. 5, Issue 1, January 2016

By applying Gram-Schmidt orthogonalization, the orthogonal base vectors for the space spanned by the channel vectors h_1^- and h_2^- can be obtained as

$$e_1 = h_1^- \\ e_2 = h_2^- - h_2^H h_1^- \qquad (15)$$

The beamforming vector w_s^* can be expressed as a linear combination of $\mu_1 \mu_2$ and $e_1 e_2$ i.e

$$w_s^* = \mu_1 e_1 + \mu_2 e_2 \qquad (16)$$

The optimal solution is given by

$$\mu_1^* = |\mu_1|^* \\ \mu_2^* = |\mu_2|^* < h_1^* h_2 \qquad (17)$$

$$|\mu_1|^* H_1 = (|\mu_1|^* H_{12} + |\mu_2|^* ||e_2||^2)^2 + \gamma_{S,D}^* |\mu_1|^* H_1 + |\mu_1|^* ||e_2||^2 = 1$$

Where μ_1 is a real number and μ_2 has phase angle $h_1^* h_2$.

IV. PERFORMANCE EVALUATION

By using MATLAB performance characteristics of MU-MIMO system for 2×2 and 4×4 is shown from figure 4 to figure 14 .

A. Results for 2×2 and 4×4 MU-MIMO configuration

Firstly the trade-off relation between EE and SE is considered. The optimal EE emphasizes the existence of a saturation point, beyond which the EE can no longer be further increased, regardless of how many additional resources are used fig. 4.

The convergence behaviour of EE and SE is analysed, which is very important for designing green communication systems and also Comparison of convergence of EE of different PRBs of 2×2 and 4×4 is get plotted fig. 5and fig. 6 from that it is clear that 4×4 MU - MIMO SE is higher than 2×2 configuration , EE is optimized as in 2×2 configuration.

EE of different PRBs, dynamic circuit power,power amplifier efficiency of 2×2 and 4×4 is compared on fromfig. 7 fig. 12 and form this plots it is clear that 4×4 MU-MIMO antenna system has better performance than2×2antenna system.

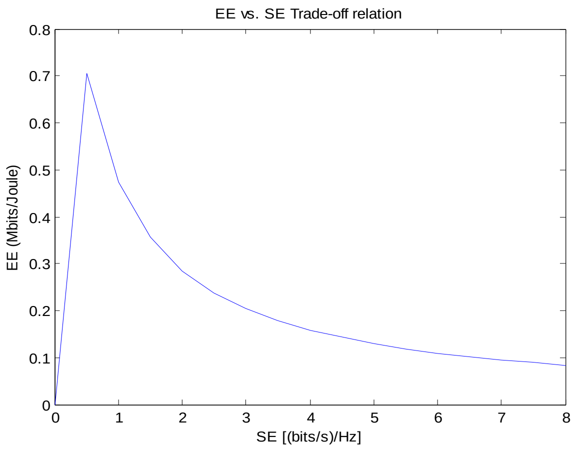


Fig.4 EEvs SE trade-off relation

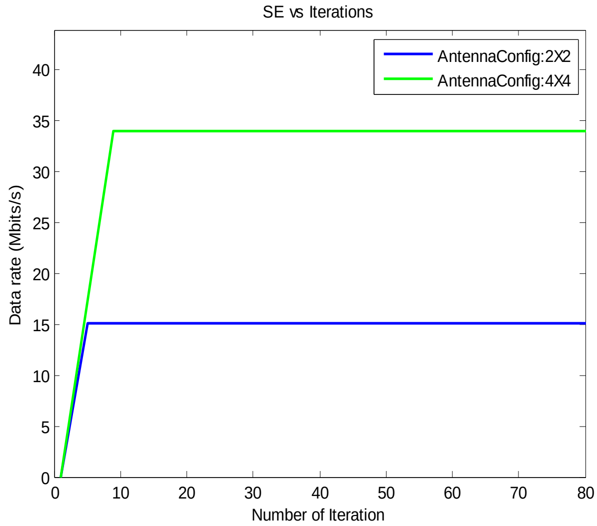


Fig. 5Spectral efficiency VS Iteration (2×2 &4×4 Configuration)

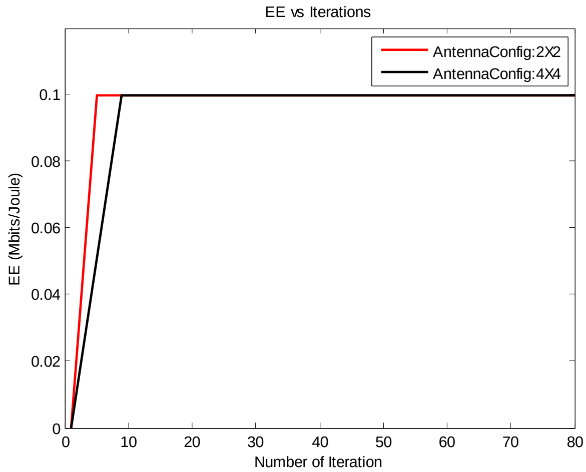


Fig.6EE vs Iteration (2×2 & 4×4 Configuration)

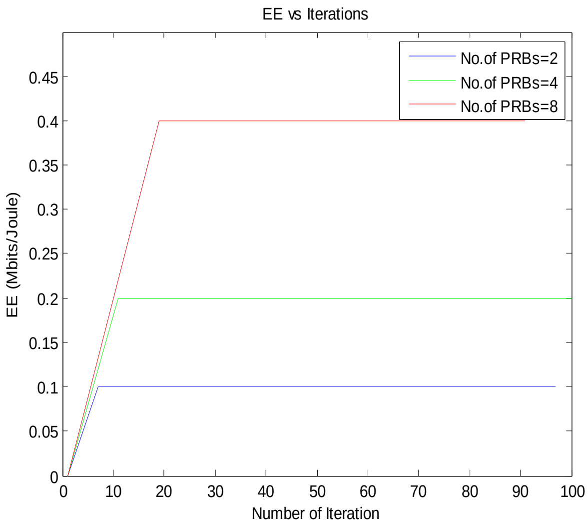


Fig. 7EE vs Iteration (2×2 & 4×4 Configuration)

IJARCCE
ISSN (Online) 2278-1021
ISSN (Print) 2319 5940
International Journal of Advanced Research in Computer and Communication Engineering
Vol. 5, Issue 1, January 2016

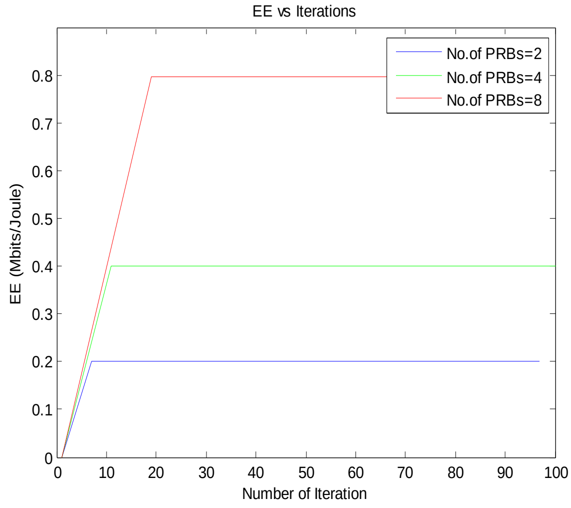


Fig. 8 EE of different PRBs (4×4 Configuration)

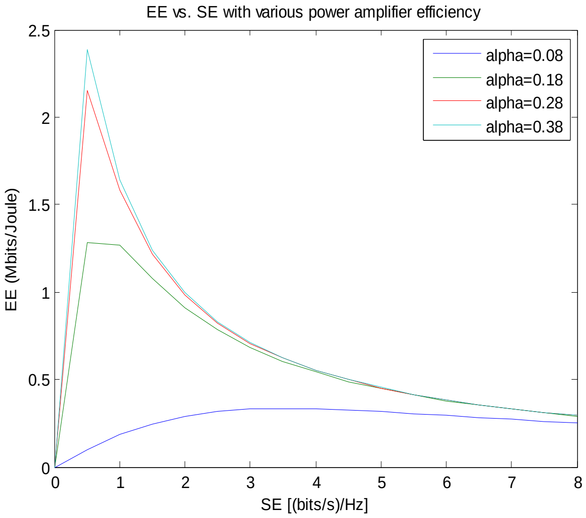


Fig. 9 EE vs SE various power amplifier efficiency (4×4 Configuration)

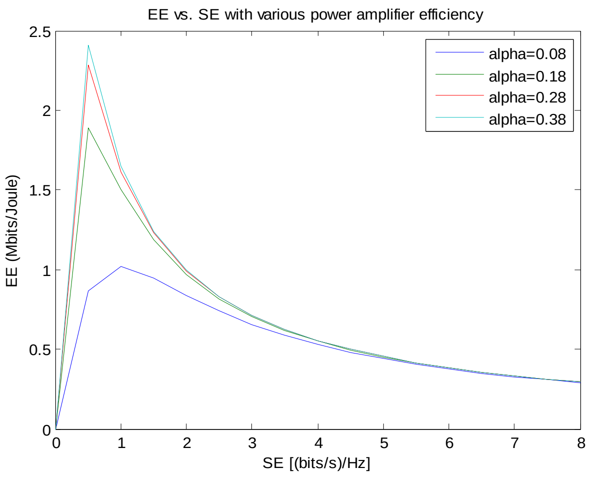


Fig.10 EE vs SE various power amplifier efficiency (4×4Configuration)

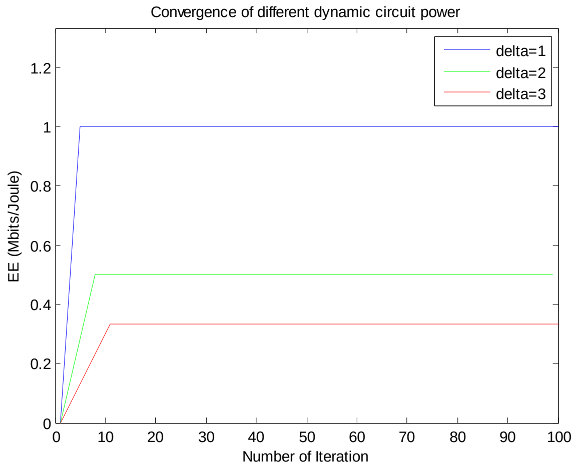


Fig. 11Convergence of different dynamic circuit power (2×2Configuration)

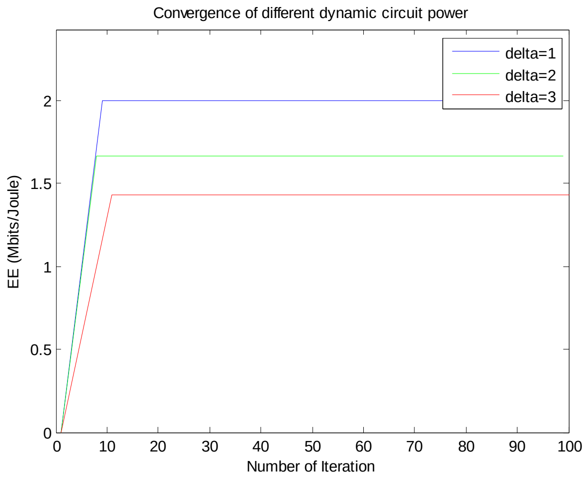


Fig. 12Convergence of different dynamic circuit power (4×4 Configuration)

B. Results for Beam forming design

Achievable transmission rate 2×2 and 4×4 is compared on fig. 13 and fig. 14. Achievable transmission rate 4×4systemis higher than 2×2.

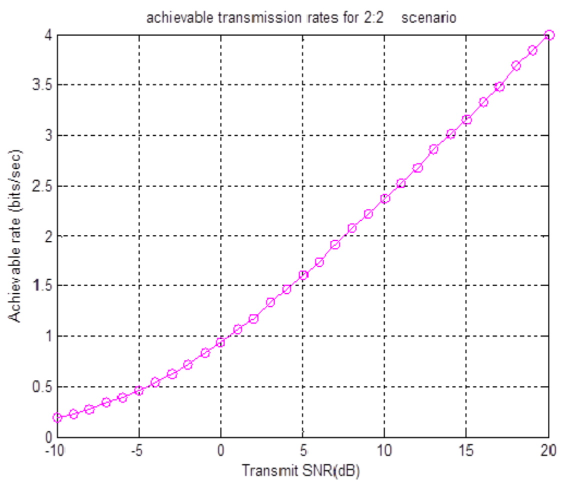


Fig. 13 Achievable rate vs SNR (2×2 Configuration)

IJARCCE
ISSN (Online) 2278-1021
ISSN (Print) 2319 5940
International Journal of Advanced Research in Computer and Communication Engineering
Vol. 5, Issue 1, January 2016

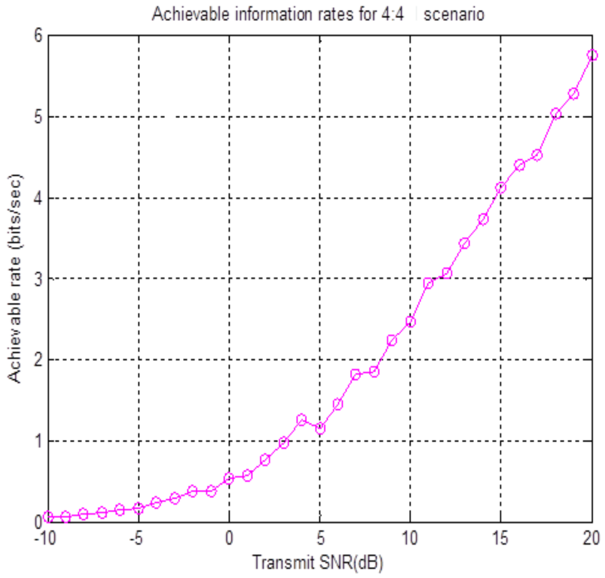


Fig. 14 Achievable rate vs SNR (4×4 Configuration)

V. CONCLUSION

The EE-SE relation in downlink 2×2 and 4×4 MU-MIMO system is considered. The convergence behaviour of EE and SE is analysed, which is very important for designing green communication systems. An analytical method to optimize energy efficiency of MU-MIMO system with respect to target SE constraints is analysed. In 4×4 MU - MIMO SE is higher than 2×2 configuration; EE is optimized as in 2×2 configuration. The behaviour of the different network parameters for 2×2 and 4×4 is compared ie, EE of different PRBs, dynamic circuit power, power amplifier efficiency, from that it is obtained that 4×4 configuration have better performance and also achievable transmission rate 2×2 and 4×4 is compared using optimal beamforming technique and it is obtained achievable transmission rate of 4×4 is higher.

REFERENCES

[1] C. Lim, T. Yoo, B. Clerckx, B. Lee, and B. Shim, "Recent trend of multiuser MIMO in LTE-advanced," IEEE Communications Magazine,vol. 51, no. 3, pp. 127–135, 2013.
[2] L. Liu, G. Miao, and J. (Charlie) Zhang, "Energy-efficient scheduling for downlink multi-user MIMO," in 2012 IEEE International Conference on Communications (ICC), Jun. 2012, p. 4394.
[3] C. H. Yu, K. Doppler, C. B. Ribeiro, and O. Tirkkonen, "Resource sharing optimization for LTE communication cellular networks," IEEE Trans. Wireless Commun., vol. 10, no. 8, pp. 2752–2763,Aug. 2011.
[4] J.Guo, F. Liu, and Z. Zhu, "Estimate the call duration distribution parameters in GSM system based on K-L divergence method," in Proc. IEEE Int. Conf. WiCom, Shanghai, China, Sep. 21–25, 2007, pp. 2988–2991.
[5] M. M. Alwakeel and V. A. Aalo, "A teletraffic performance study of mobile LTE cellular networks with gamma distributed call duration," IEEE Trans. Veh. Technol., vol. 55, no. 2, pp. 583–596, Mar. 2006.

BIOGRAPHY

Chithra B Das received the B.Tech degrees in Electronics and Communication Engineering from CUSAT, Kerala at College Of Engineering Adoor. And now she is pursuing her M.Tech degree in Communication Engineering under MG University, in Mount Zion College of Engineering, Kadammanitta, Pathanamthitta.