PERFORMANCE ANALYSIS OF RESOURCE ALLOCATION DOWNLINK FOR MIMO-OFDMA SYSTEM USING GREEDY ALGORITHM

Azrinawati Binti Samaon
Faculty of Electrical Engineering,
Universiti Teknologi Mara (UiTM)
40450 Shah Alam, Selangor.Malaysia.
rienaptraja@gmail.com

Abstract— **Finding the optimization of power allocation of subcarrier is always a challenge in MIMO-OFDMA schemes in order to maximize the capacity of the system. Resources allocation is process how set of network is decide in wireless system. This research is to study restriction of proportional rate and total power among user in MIMO-OFDMA scheme and the power allocation and capacity of subcarrier in the scheme. The objectives are to suggest by using Greedy Power Allocation for capacity increment in MIMO-OFDMA system and to evaluate the system by Greedy Subcarrier Allocation. Simulation results show that the proposed algorithm can improve the capacity of the network compared with the waterfilling when using signal-to-noise ratio (SNR) with value 6dB. The proposed algorithm shows comparison between the noise to sub-channel ratio and power allocation in the midst of data sub-channel for 25, 75 and 100 users. It shows that there is no significant difference in power allocation of data subcarriers even if the number of users is increased.**

Keywords—Resource Allocation, MIMO-OFDMA, Greedy Algorithm, Power Allocation, Subcarrier Allocation.

I. INTRODUCTION

Many advanced technologies of wireless communication systems to start with the Multiple-Input Multiple-Output (MIMO) system [1][12]. One example of the communication systems that implemented with MIMO is the Long Term Evolution (LTE). The communication system capacity was proved can be enhanced by using the widely-used MIMO technology and it also increases the reliability of the communication link. The technology uses various schemes beyond the spatial diversity.

The usage of plentiful antennas at the transmitter and receiver in MIMO technology has improved the reliability of transmission. Some examples of applications that using this technology are Wireless Local Area Networks (WLANs), satellite-based network, and wireless mobile radio system. Nowadays, the competences, efficacy and performance in the wireless technology are amplified by using the 3rd Generation Partnership Project (3GPP) LTE.

The well-developed MIMO-OFDMA is the connection between Orthogonal Frequency Division Multiple Access (OFDMA) and MIMO technology. The aim of this combination is to gain better improvement of data rate particularly usage in wireless technology for 4th Generation (4G). Orthogonal signal among user are acknowledged as the orthogonal approaches. Frequency Division Multiple Access (FDMA), Orthogonal Frequency Division Multiple Access (OFDMA) and Time Division Multiple Access (TDMA) are the kinds of orthogonal Multiple Access (MA) [2][19]. For OFDMA which all data are transmitted in parallel, the present of spectrum is separated into multiple orthogonal narrowband sub-channel called subcarrier which each carrier is simultaneously allocated solely to one user. [2][3][18].

The optimality of downlink MIMO-OFDMA system has been considered in many researches. The noteworthy method of MIMO which has enhanced the performance of wireless system was discussed by authors in [5]. Numerous antennas are employed at both the receiver and transmitter in MIMO system in order to establish spatial diversity and in the meantime the OFDM potentially fulfilling the need of high data rate transmission. Flexibility in control on capacity, complexity and equality of a new adaptive resource allocation scheme was also proposed by authors in [5]. In OFDMA, the improvement of spectrum efficacy can be achieved by manipulating the frequency and multiuser diversity. In the scheme, the fairness is initially to improve using priority based on scheduling technique and a Tradeoff-Factor (TF) is to bring into scheme. This is to rearrange subcarrier in the midst of user to get the most fairness gain and least capacity loss under the alleged algorithm design criterion. As published in [6], the proposed scheme are using for resource allocation in MIMO-OFDMA scheme for downlink system.

In devising an adaptive resource allocation scheme, some issues need to be taken into consideration. The issues such as capacity enhancement, complexity reduction and fairness improvement are the typical ones deliberately considered. The focuses of majority of the algorithms discussed in the literature are the minimization of overall transmits power and the maximization of data rate to fulfill the requirements of QoS. An algorithm called Greedy Power Allocation (GPA) is used for multiuser OFDMA system was studied in [9] in order to find the best probable resolution for the adaptive resource allocation issue with proportional restriction. The system is sum-rate capacity and then will maximize by solving the mathematical complexity and achieving approximate rate proportionality in [10].

The fairness of data rate is another problem that has been given much attention regarding resource allocations. The achievement of great performance in convergence and the proportional fairness among the users is the result of improvement in Subcarriers Allocation (SA) and Genetic Algorithm (GA) thus the complexity is also reduced [10]. Dominant Eigen-channel that is gain from MIMO state matrix is used to maximize the proportional fairness and the total system capacity with restrict on the sum of available power. Low complexity enables the control of capacity and fairness. Resources allocation problem could be simplified by divide of subcarrier and power allocation where the algorithms will achieve proportionally approximate rate. This will maximized the capacity and the computational complexity will be reduced [11][13][14]. As mentioned in [10], the problem of power optimization in MIMO-OFDMA system is solved by applying Lagrange multipliers technique. The algorithm will optimized the Eigen-channel allocation in the system capacity and power allocation in the system by maximizing the fairness levels between of active users.

II. SYSTEM MODEL

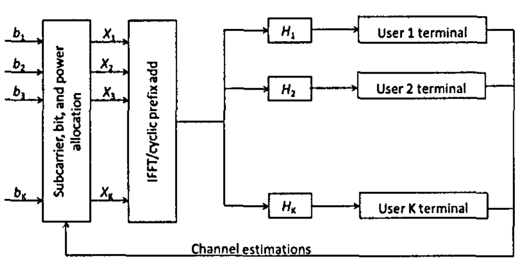

Fig. 1 MIMO-OFDMA in the model of downlink system

Figure 1 shows the block diagram in the downlink of MU-OFDMA system at base station transmitter. $P_{k,n}$ is the power set by allocating bits in different K user to N subcarrier which subcarrier n $(1 \leq n \geq N)$ of user k $(1 \leq k \geq K)$ [4].

MIMO channel is evenly allocated and divided to multiple users. Each of user channels has access to space domain over entire transmission channel and frequency bandwidth. The most critical problem for MU-MIMO in LTE is CSI feedback overhead, the different among Multi-user performance obtained, an efficient scheduling methodology, as well as low-complexity transceiver design.

Therefore, the objective is principally to analyse and compare the power allocation and subcarrier of MIMO-OFDMA between the Greedy and Waterfilling Algorithm to perform the objectives of resource allocation based on MIMO-OFDMA schemes for the application of LTE downlink system.

III. PROPOSED ALGORITHM

Generally the resource allocation (RA) is to state in a constrained optimization problem:

(1) Minimize the sum of transmit power with a constraint on the data user

(2) Maximize the sum of data rate with a constraint on total transmit power.

A. Problem Formulation

The following formula is used to compute the signal to noise ratio (SNR) for each subcarrier:

$$\gamma_n = \frac{Pn\hat{H}n^2}{\sigma^2 + Pn\sigma^2_{\epsilon n}} \tag{1}$$

Where:

γ = signal to noise ratio

P_n=*the transmitted power*

$\hat{H}_n^2$ =*the estimated channel response in frequency*

σ^2 = *the AWGN noise power at each sub channel*

$\sigma^2_{\epsilon,n}$ =*created noise due to channel estimation based on MMSE*

Greedy:

Formulation of the problem of the resource allocation with proportional rate constraints is shown below:

$$\max_{C_{k,n},P_{k,n}} \frac{B}{N}\sum_{k=1}^{K}\sum_{n=1}^{N} C_{k,n}\log_2(1+P_{k,n}H_{k,n}) \qquad (2)$$

Where:
$C_{k,n}$ = subcarrier allocation indicator
$P_{k,n}$ = allocated power
K= users
N= subcarrier
B= bandwidth
$H_{k,n}$ = subcarrier SNR

The power of each user in the system is computed as follows:

$$P_k = \sum_{n=1}^{N} C_{k,n}P_{k,n} \qquad (3)$$

Where:
P_k = power of each user.

Greedy algorithm for all users to calculate the total sum-rate capacity of the system:

$$R^{gpa} = \sum_{k=1}^{K} R_k^{gpa} \qquad (4)$$

Where:
R^{gpa}= capacity greedy power allocation

Waterfilling:

To compute the best power allocation, given the total amount of power allocated to pilot. The maximum of the total capacity is required in the multi-user system. Sub-channel allocation is doing by allocating each sub-channel to a user that response to the best sub-channel.

The power allocation between users is represented by:

$$\max \sum_{n}^{N_s} \log_2\left(1+\frac{Pn\hat{H}n^2}{\sigma^2+Pn\sigma_\epsilon^2}\right) \qquad (5)$$

Subject to:

$$P_s = \sum_{n}^{N_s} P_n \qquad (6)$$

Where:
P_s = total power for data transmission.
N_s = number data of subcarrier.

Lagrangian approach is applied to solve this problem by setting the derivation of Lagrangian function to zero.

The formula below is used to compute the maximization of capacity:

$$\max \sum_{n}^{N_s} \log_2\left(1+\frac{\hat{H}_n^2}{\frac{\sigma^2}{Pn}+\sigma_\epsilon^2}\right) \qquad (7)$$

Given the situation:

$$\sum_{n}^{N_s} P_n = P_s = \alpha P_T \qquad (8)$$

$$N_p P_P = P_p = (1-\alpha)P_T \qquad (9)$$

$$N = N_p + N_s \qquad (10)$$

Where:

N_p = the number of pilots in each block.
P_p = the total power allocated to subcarriers.
P_T = the total available transmission power.
α = ratio of total power allocated to data subcarrier.

IV. RESULT AND DISCUSSION

In this research, the considered MIMO-OFDMA transmission could rectify the problem to optimize the transmit power allocation to achieve high capacity. Waterfilling algorithm and greedy algorithm are used to find the optimum power allocation for each subcarrier and capacity.

The simulation is done based on the parameter listed in as reference [13]:

Parameter	Value
Number (Sub-channels)	16
Total Power (Watt)	1
Bandwidth (B)	$3\text{x}10^6$
Noise	$1\text{x}10^{-8}$
Channel gain for users in different sub channels	0.001, 0.9,0.4
Total subcarrier (pilots and data)	64
Subcarriers (pilots)	16
Vector of pilot (number for simulation)	8,16,32
Number of users (system)	25,75,100
Average SNR (dB)	6

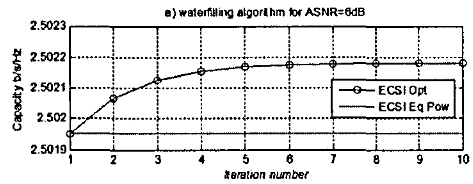

Fig 2. Performance convergence of waterfilling algorithm for (25 users)

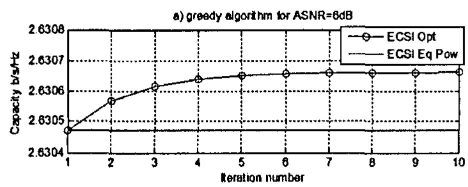

Fig3. Performance convergence of greedy algorithm (25 users).

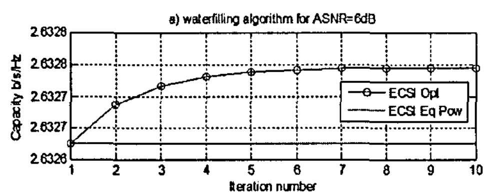

Fig 4. Performance convergence of waterfilling algorithm (75 users)

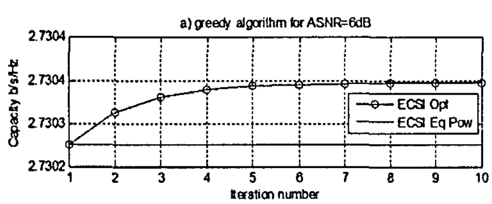

Fig 5. Performance convergence of greedy algorithm (75 users)

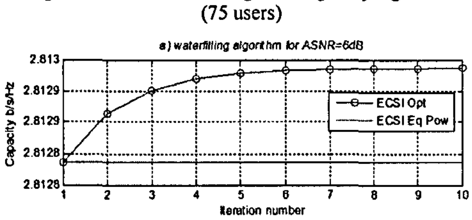

Fig 6. Performance convergence of waterfilling algorithm (100 users)

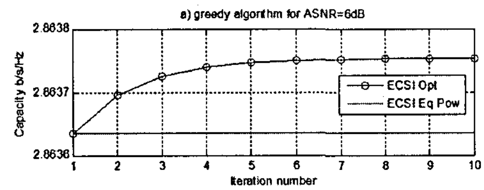

Fig 7. Performance convergence of greedy algorithm (100 users)

Figure 2,3,4,5,6 and 7 show the comparison performance convergence between waterfilling and greedy algorithm using ASNR 6 dB. The figures show that the algorithm converges to the optimum point from the initial point within a few number of iterations, which is the equal power allocation and different user.

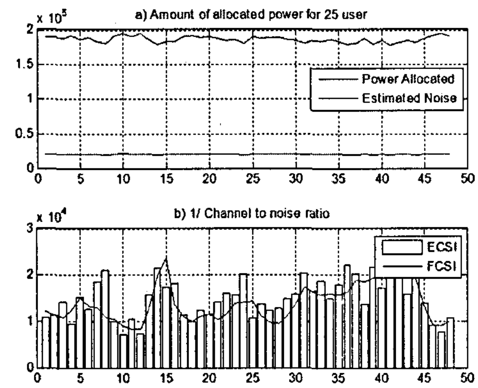

Fig 8. Comparison distribution of power versus channel state information waterfilling algorithm (25 users)

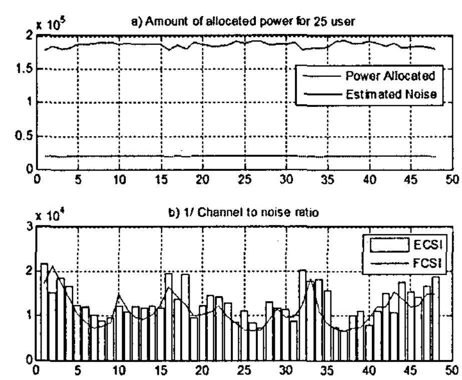

Fig. 9. Comparison distribution of power versus channel state information greedy algorithm (25 users)

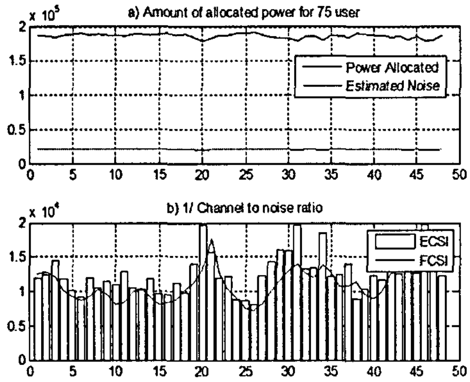

Fig 10. Comparison distribution of power versus channel state information water-filling algorithm (75 users)

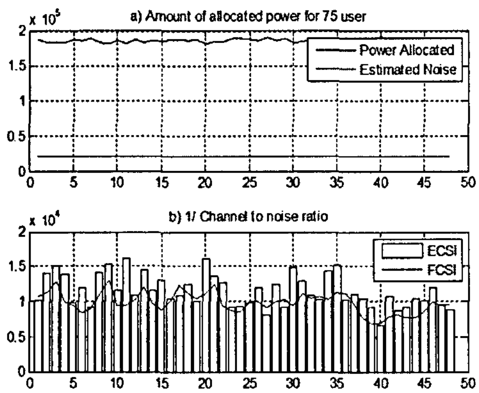

Fig. 11. Comparison distribution of power versus channel state information greedy algorithm (75 users)

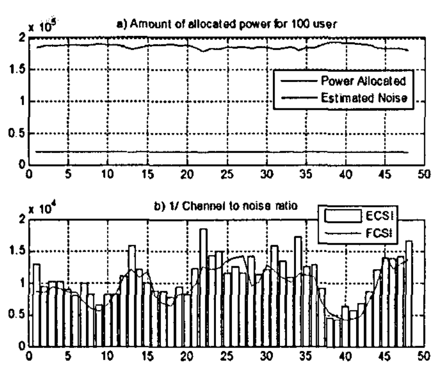

Fig. 12 Comparison distribution of power versus channel state information water-filling algorithm (100 users)

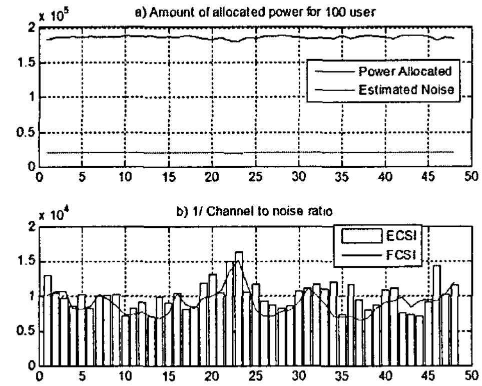

Fig 13. Comparison distribution of power versus channel state information greedy algorithm (100 users).

TABLE 1

TABLE 1. Comparison Greedy Algorithm respect to Water-filling Algorithm

User		Greedy Algorithm	Water Filling Algorithm	Remarks
25	Capacity (b/h/Hz)	2.6307	2.5022	Greedy Algorithm increase 5.1%
	Power Allocation	No significant difference		
	FCSI	No significant difference		
75	Capacity (b/h/Hz)	2.7304	2.6328	Greedy Algorithm increase 3.7%
	Power Allocation	No significant difference		
	FCSI	No significant difference		
100	Capacity (b/h/Hz)	2.8638	2.813	Greedy Algorithm increase 1.8%
	Power Allocation	No significant difference		
	FCSI	No significant difference		

Figure 8,9,10,11,12 and 13 show the comparison between power allocation in the midst of data sub-channel and the noise to sub-channel ratio for three different number of users which are 25,75 and 100. The blue curves in each of Part a) of the figures represent the power allocated whereas the red curves represent the estimated noise. Meanwhile the white bars in Part b) of figures represent the Estimated Channel State Information (ECSI) and Full Channel State Information (FCSI) present by the blue curves.

From the result, it shows that the Greedy Algorithm approach increases the capacity compared to the Waterfilling Algorithm for 25, 75 and 100 users by 5.1%, 3.7% and 1.8% respectively. In the meantime, there are no significant difference between the Greedy Algorithm and Waterfilling Algorithm in power allocation and Full Channel State Information (FCSI).

CONCLUSION AND RECOMMENDATION

A. Conclusion

This paper presents the comparison in performance capacity between the greedy and waterfilling algorithm for different users. These algorithms are run under MATLAB environment. Greedy algorithm is improved in term of capacity compare with the water-filling algorithm. From the results obtained, percentages of capacity will be increased and distribution of power allocated among the users is evenly equal to each other. In the MU-OFDMA system, the optimize power allocation is computed by minimum mean square estimation (MMSE) channel estimation analytically. Additionally, results show that the optimum performance is not differing to the equal power allocation at average signal to noise ratio (ASNR) greater than 6dB.

B. Future Recommendation

This research can further be used to enhance the optimization of greedy algorithm to resolve the issue of providing fair rate data to the user. This proposed method to be implemented in wireless system of downlink transmission.

References

[1] W. Ajib, D. Haccoun, "An overview of scheduling algorithms in MIMO-based fourth-generation wireless systems," in Network, IEEE , vol.19, no.5, pp.43-48, Sept.-Oct. 2005

[2] Peng Wang, Jun Xiao and Li Ping, "Comparison of Orthogonal and Non-Orthogonal Approaches to Future Wireless Celular System,".

[3] Murtadha, A. N, P. Maninder, "SC-FDMA & OFDMA in LTE physical layer," in International Journal of Engineering Trens andTechnology , vol.12, no.2, pp.74-85, Jun 2014.

[4] Najib A.O, Moawad I. D, Waleed E Al-Hanafy, Fathi E, Abd El-samie,"Low Complexity Greedy Power Allocation Algorithn for Proportional Resource Allocation in Multi-User OFDM System," in Journal of Telecommunications And Information Technology, pp.38-45, April 2012.

[5] Bin Da, C.C.Ko "Resource Allocation in Downlink MIMO-OFDMA with Proportional Fairness," in Journal of Communications, vol.4, no.1, February 2009.

[6] Jian Xu, Jongkyung Kim, Wonkyu Paik and Jong-Soo Seo, "Adaptive Resource Allocation Algorithm with Fairness for MIMO-OFDMA System," in Vehicular Technology Conference, 2006. VTC 2006-Spring. IEEE 63rd , vol.4, no., pp.1585-1589, 7-10 May 2006.

[7] Fan, Jiancun, Qinye Yin, Li, G.Y., Peng, Bingguang; Xiaolong Zhu, "Adaptive Block-Level Resource Allocation in OFDMA Networks," in Wireless Communications, IEEE Transactions on , vol.10, no.11, pp.3966-3972, November 2011.

[8] Ali, M.A., Al-Ghadhban, S.,Mahmoud, A.S.H., "Resource allocation scheme for MIMO-OFDMA systems with proportional fairness constraints," in Wireless and Mobile Computing, Networking and Communications (WiMob), 2012 IEEE 8th International Conference, vol., no., pp.512-516, 8-10 Oct. 2012

[9] I. wong., Z, Shen., B, Evans., and J, Andrews, " A low Complexity Algorithm for Proportional Resource Allocation In OFDMA System," in Proc.IEEE Worksh. Sig. Proces. Syst. SIPS 2004,Austin, Texas, USA, 2004. pp.1-6.

[10] K. Sumathi, and M.L Valarmathi,"Adaptive Resource Allocation in MIMO-OFDMA based on Subcarrier Allocation (SA) and (GA)," in International Journal of Computer Applications, vol.49, no.19, pp.41-48, July 2012.

[11] Jie Zhao, Youming Li, "An efficient proportional resource allocation algorithm in MIMO-OFDMA systems," in Mobile Congress (GMC), 2011 Global , vol., no., pp.1-6, 17-18 Oct. 2011

[12] Farooq Khan, "LTE for 4G Mobile Broadband," Cambridge University Press 2009

[13] Hamid M. Ramezani, "Capacity Maximization in Multiuser OFDMA system, based on estimated channel information," http://ens.ewi.tudelft.nl/~ramezani/publications.html.

[14] Babul Reddy, K.Gopi and Dr.T.Rama Shri, "Capacity Maximization in Multiuser OFDMA – WMN System," in International Journal of Computer Trends and Technology (IJCTT), vol 5, no.3, Nov 2013

[15] S. Najeh, H. Besbes and A. Bouallegue, "Greedy Algorithm for Dynamic Resource Allocation in Downlink of OFDMA System," 2005 2nd International Symposium on Wireless Communication Systems, Siena, 2005, pp. 475-479.

[16] Bin Da, C. C. Ko and Yanfen Liang, "An enhanced capacity and fairness scheme for MIMO-OFDMA downlink resource allocation," Communications and Information Technologies, 2007. ISCIT '07. International Symposium on, Sydney,. NSW, 2007, pp. 495-499.

[17] Ying Jun Zhang and K. B. Letaief, "An efficient resource-allocation scheme for spatial multiuser access in MIMO/OFDM systems," in IEEE Transactions on Communications, vol. 53, no. 1, pp. 107-116, Jan. 2005.

[18] Q. H. Spencer, C. B. Peel, A. L. Swindlehurst and M. Haardt, "An introduction to the multi-user MIMO downlink," in IEEE Communications Magazine, vol. 42, no. 10, pp. 60-67, Oct. 2004.

[19] Cheong Yui Wong, R. S. Cheng, K. B. Lataief and R. D. Murch, "Multiuser OFDM with adaptive subcarrier, bit, and power allocation," in IEEE Journal on Selected Areas in Communications, vol. 17, no. 10, pp. 1747-1758, Oct 1999.

[20] Sudhir B. Lande, Dr. J. B. Helonde, Dr. Rajesh Pande, "Comparison of Resource Allocation Techniques in OFDMA for Wireless communication," in International Journal of Engineering and Innovative Technology, vol. 2, Issue 6, Dec. 2012.