Development of Efficient Resource Allocation Algorithm in Chunk Based OFDMA System

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Abstract. The emerging demand for diverse data applications in next generation wireless networks entails both high data rate wireless connections and intelligent multiuser scheduling designs. The orthogonal frequency division multiple access based system is capable of delivering high speed data rate and can operate in a multipath environment. OFDMA based system dividing an entire channel into many orthogonal narrow band subcarriers. Due to this, it is useful to eliminate inter symbol interferences which is a limit of total available data rates. In this paper, investigation about resource allocation problem for the chunk based Orthogonal Frequency Division Multiple Access (OFDMA) wireless multicast systems is done. In this paper, it is expected that the Base Station (BS) has multiple antennas in a Distributed Antenna System (DAS). The allocation unit is a group of contiguous subcarriers (chunk) in conventional OFDMA systems. The aim of this investigation is to develop an efficient resource allocation algorithm to maximize the total throughput and minimize the average outage probability over a chunk with respect to average Bit Error Rate (BER and total available power).

Keywords— MISO-OFDMA, multicast system, DAS, multiuser diversity, chunk allocation**.**

1 INTRODUCTION

The systems based on OFDMA, are able to deliver high data rate and can operate in the hostile multipath radio environment. OFDMA-based systems allow efficient sharing of limited resources among multiple users such as spectrum and transmit power [1]-[3].

With various Quality-of-Service (QoS) requirements OFDMA has been developed to support various multimedia applications. The frequency band divides into a group of mutually orthogonal subcarriers in OFDMA, each group having a much lower bandwidth than the coherence bandwidth of the channel. It provides better protection facility to inter symbol interference and frequency selective fading. Each user is dynamically assigned to a subset of subcarriers in multi-user environment in each frame which take advantage of the fact that at any time, the channel responses are different for different users and at different subcarriers [2]-[7].

In Chunk Based OFDMA Resource Allocation with Single Antenna Scenario, the allocation algorithm allocated chunks to users according to their average Signal to Noise Ratio within each chunk, where Bit Error Rate (BER) is make-sure within each chunk. Chunk based resource allocation is applied not only to the single antenna scenario but also to the multiple antennas [8]-[10]. The resource allocation in chunk based OFDMA with single antenna scenario has low throughput. Total system throughput can be increased by placing BS's multiple antennas at different locations. Resource Allocation is performed centralized in Distributed Antenna System and the available resources are used more efficiently. It is possible because of the different spreading environments across distributed antennas that to make better the wireless channels of users. Through a single transmission, data can be transmitted from each distributed antenna of the base station to multiple mobile users only in multicast systems [11]-[13].

2 PROPOSED MODEL FOR EFFICIENT RESOURCE ALLOCATION ALGORITHM

To design an efficient algorithm for resource allocation in OFDMA, consider two cells with N total number of subcarriers, T is the number of distributed antennas, K is the total number of active users. Assume the overall bandwidth is B, the total transmitting power is P_{total}, and the one sided power spectral density of additive white Gaussian noise is N_o.

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DOI: 10.1051/matecconf/20165701006

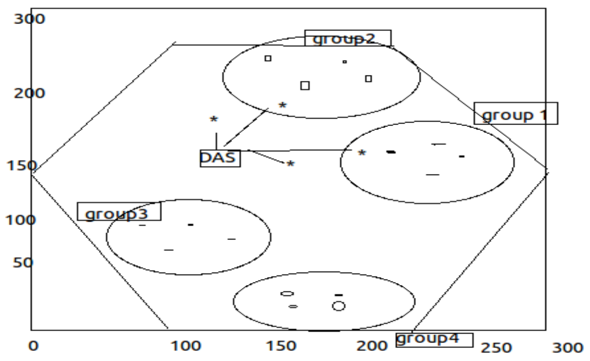

Figure 1. Cell-1 for N=1024, T=4, K=20, G=4

In figure 1, a cell-1 with total number of subcarriers N= 1024, total number of distributed antennas T=4, total number of active users K= 20, total available bandwidth B= 100MHz, group of subcarriers G=4, frequency separation between two contiguous subcarriers is df= 100MHz/1024 =97.6 KHz. Group of subcarriers (Chunk) is done randomly by taking the minimum number of active users 1 and maximum number of active users are 7. Users are placed in cell-1 area uniformly. In DAS (Distributed Antenna System) one antenna is placed at the center of the cell and other antennas are placed at a fixed distance from the center base antenna. For all users in cell-1, coherence bandwidth f_c is same. Here two different values of coherence bandwidth f_c is examined, f_c = 1.95 MHz and f_c = 0.49 MHz. Path loss exponent for cell-1 is 5.

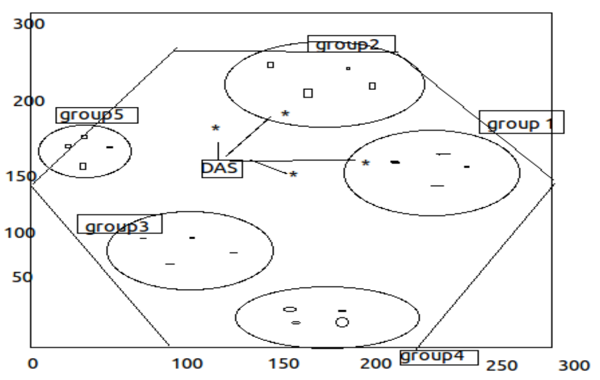

Figure 2. Cell-2 for N=1024, T=4, K=20, G=5

In figure 2, cell-2 with total number of subcarriers N= 1024, total number of distributed antennas T=4, total number of active users K= 20, total available bandwidth B= 100MHz, group of subcarriers G=5, frequency separation between two contiguous subcarriers is df= 100MHz/1024 =97.6 KHz. Chunk is done randomly by taking the minimum number of active users is 1 and maximum number of active users are 7. Users are placed in cell-2 area uniformly. In DAS (Distributed Antenna System) one antenna is placed at the center of the cell and other antennas are placed at a fixed distance from the center base antenna. For all users in cell-2, coherence bandwidth f_c is same. Here two different values of coherence bandwidth f_c is examined, f_c = 1.95 MHz and f_c = 0.49 MHz. Path loss exponent for cell-2 is 5.

Let us consider the T ×1 complex Gaussian distribution frequency response vector is $h_{k,n}= [h^1_{k,n}, h^2_{k,n}, h^3_{k,n} \ldots\ldots h^T_{k,n}]^T$ between user of k and base station in subcarrier n. The magnitude of this complex Gaussian distribution frequency response vector $h_{k,n}$ will be $|h_{k,n}|$. This magnitude function will follow $E[|h_{k,n}|^2]$ which is the Rayleigh distribution.

Channel gain vector vector between the user k and the base station is given by T ×1 matrix.

$g_{k,n}= [g^1_{k,n}, g^2_{k,n}, g^3_{k,n} \ldots\ldots g^T_{k,n}]^T$ is (1)

Where

$$g^t_{k,n} = D^{-\alpha}_{k,t} |{}^{ht}{}_{k,n}|^2 \quad (2)$$

for t=1,2,3…..T

$D^{-\alpha}_{k,t}$= path loss

α= path loss exponent

By using a single transmission, from each distributed antenna of the base station (BS) data can be transmitted to multiple mobile users in multicast wireless communication system. In this case, the number of active users K are grouped in a number of chunks G. These all users are related to set

$$K= U^G_{g=1} K_g \quad (3)$$

and $|K| = U^G_{g=1} |K_g|$ (4)

where K_g= user set of group g

In a multicast group, the channel quality of every user may be different. Within each group, the base station of distributed antenna system transmits data rate at the lowest of all users. In each distributed antenna, this data rate is calculated by the user with the smallest channel gain.

The equivalent channel gain vector of g will be

$$a_{g,n} = [a^1_{g,n}, a^2_{g,n}, a3_{g,n} \ldots\ldots a^T_{g,n}]^T \quad (5)$$

where $a^1_{g,n}= \min_k \epsilon\, Kg\, g^t_{k,n}$ for t=1,2,3…….T

The equivalence model of the baseband for the system by using beam forming will be

$$y_n = A_n W_n D_n s_n + z_n \quad (6)$$

where

y_n = received signal vector of G×1 matrix

A_n= G×T channel matrix= [$a_{1,n}, a_{2,n}, a_{3,n} \ldots\ldots a_{G,n}$]

W_n = T×G beam forming weight matrix = [$w_{1,n}, w_{2,n}, w_{3,n} \ldots\ldots w_{G,n}$]

$w_{g,n}$ = T×1 beam forming weight vectors in subcarrier n for group g

$$w_{g,n} = [w^1_{g,n}, w^2_{g,n}, w3_{g,n} \ldots\ldots w^T_{g,n}]^T \quad (7)$$

D_n = power distribution among G multicast groups to subcarrier n

s_n = transmitting signal vector of G×1 matrix

z_n = noise vector of G×1 matrix

In the proposed scheme, L-ary QAM (L-ary Quadrature Amplitude Modulation) is used as a modulation scheme, where L is the modulation levels.

$$L = \{0, 2^2, 2^4 \ldots\ldots 2^b \ldots\ldots, 2^B\} \quad (8)$$

Where in QAM, b is the number of bits

i. When the number of bits b is equal to 0 then than there will be no transmission.

ii. When the number of bits b is equal to B then the transmission rate will be equal to B. It means the system will get highest modulation level.

By using Zero Forcing (ZF) beam forming, if G>T, this case is not use because $A^*_n (A_n A^*_n)^{-1}$ will be a singular. Due to this, it will be a need to select t out of G multicast groups where t less than or equal to G in each subcarrier. Due to this, there will be I possible number of combinations of multicast groups which will transmit to the same subcarrier B_n.

If G is less than or equal to T and rank of A_n is equal to G than beam forming matrix will be

$$W_n = A^*_n (A_n A^*_n)^{-1} \quad (9)$$

A set of multicast groups

$B_n = \{s_1, s_2, s_3 \ldots\ldots\ldots\ldots S_t\}$ in each subcarrier like

$$An(Bn) = \{a_{s1,n}, a_{s1,n}, a_{s1,n}, \ldots\ldots\ldots\ldots a_{st,n}\} \quad (10)$$

When Zero Forcing is used than the effective channel of multicast group g will be

$$C_{g,n} (B_n) = \{[(An(Bn)\ An(Bn)^*)^{-1}]_{g,g}\}^{-1} \quad (11)$$

If it is used water filling equation for the calculation of total power than Zero Forcing beam forming matrix becomes

$$W_n (B_n) = A_n(Bn)^* (An(Bn)\ An(Bn)^*)^{-1} \quad (12)$$

To reduce the system overhead, the N numbers of subcarriers are grouped into C chunks. Usually the coherence bandwidth f_c exceeds the subcarrier bandwidth f_s. Assume that the total number of chunks C= N/N' are integer, where N' is the total number of subcarriers in a chunk.

Steps for calculation of Average throughput and Outage Probability: Take value for all parameters. Set number of cell=2, set dummy array at u={1,2….7} and set minimum active user and maximum active user, $K_{min.}$=1 and $K_{max.}$=7. Resource allocation is done by using allocation = histc(user_subband.*user_activated, 1:N)'.

1. Set number of chunks M={1,2....G).
2. Calculate BER, BER= e/T', where e is the number of bit error and T is the total no of transfer bit during studied time interval.
3. Calculate SNR by using SNR= $(1/BER)^m$, where m is the number of modulation scheme.
4. Calculate throughput by using throughput=$(1-BER)^n$, where n is the number of subcarriers.
5. For a multicast group, calculate the average throughput by using average throughput=$1/n\sum^n_{i=1}(a1+a2\ldots\ldots.a7)$, where a1, a2….a7 are the values of throughput, and calculate average outage probability.

3 SIMULATION AND RESULTS

The performance of the proposed algorithm assess by using simulation in MATLAB. Number of subcarriers N=1024, Number of Antennas T=4, Bandwidth B=100MHz, Coherence Bandwidth f_c = 1.95MHz and 0.49MHz, Frequency Separation df = 97.6 KHz, P ath Loss Exponent α = 5, $M_{min.}$, number of users in a chunk $K_{min.}$ = 1, $M_{max.}$ number of users in a chunk $K_{min.}$ = 7

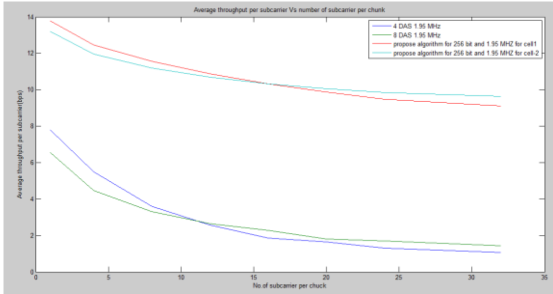

Figure 3. Average throughput per subcarrier vs number of subcarriers per chunk for f_c = 1.95MHz

As Shown in figure 3, a graph is plotted between average throughput per subcarrier and number of subcarrier per chunk at coherence bandwidth f_c = 1.95MHz. In this, as increasing the number of chunks the Average throughput per subcarrier decreases. By comparing the results, as number of subcarriers per chunk are 18 than the average throughput for 256-DAS in cell-1 (number of chunks are 4) gives better throughput than 256-DAS in cell-2 (number of chunks are 5), 4-DAS and 8-DAS. As increasing the number of subcarriers per chunk from 18, the average throughput for 256-DAS in cell-2 is better than 256-DAS in cell-1, 4-DAS and 8-DAS. As number of subcarriers per chunk is 12, at this point the average throughput per subcarrier is 10.8811 for 256-DAS in cell-1 and 10.332 for 256-DAS in cell-2 which are much better than, 8-DAS and 4-DAS.

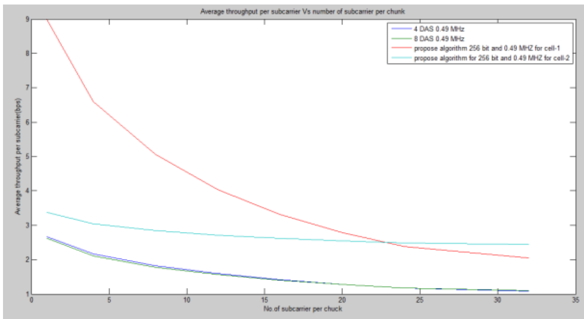

Figure 4. Average throughput per subcarrier vs number of subcarriers per chunk for f_c = 0.49MHz

In figure 4, as increasing the number of chunks the Average throughput per subcarrier decreases. By comparing the results, the average throughput for 256-DAS in cell-1 (number of chunks are 4) gives better throughput than 256-DAS in cell-2 (number of chunks are 5), 4-DAS and 8-DAS. As number of subcarriers per chunk is 12, at this point the average throughput per subcarrier is 4.0309 for 256-DAS in cell-1 which is much better than 256-DAS in cell-2, 8-DAS and 4-DAS.

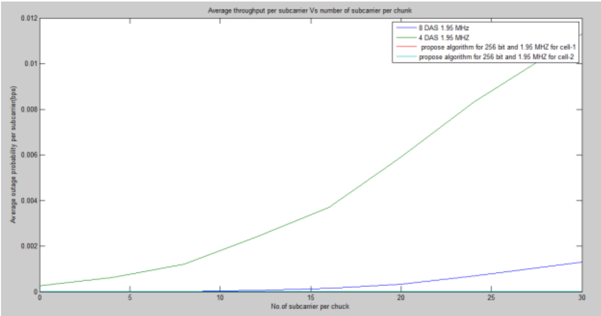

Figure 5. Average outage probability per subcarrier vs number of subcarriers per chunk for f_c = 1.95MHz

In figure 5, as increasing the number of chunks the Average outage probability per subcarrier increases. By comparing the results, the average outage probability for 256-DAS in cell-1 (number of chunks are 4) is much less than the 256-DAS in cell-2 (number of chunks are 5), 4-DAS and 8-DAS. As number of subcarriers per chunk is 12, at this point the average outage probability per subcarrier is $.05\times10^{-6}$ for 256-DAS in cell-1 which is much better than 256-DAS in cell-2, 8-DAS and 4-DAS.

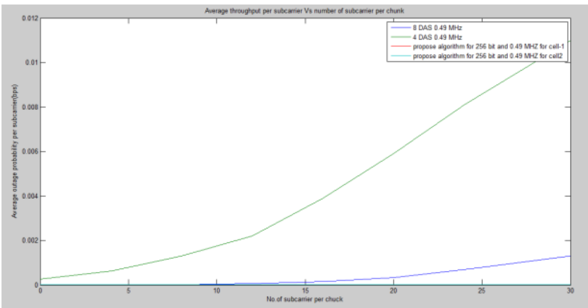

Figure 6. Average outage probability per subcarrier vs number of subcarriers per chunk for f_c = 0.49MHz

In figure 6, as increasing the number of chunks the Average outage probability per subcarrier increases. By comparing the results, the average outage probability for 256-DAS in cell-1 (number of chunks are 4) is much less than the 256-DAS in cell-2 (number of chunks are 5), 4-DAS and 8-DAS. As number of subcarriers per chunk is 12, at this point the average outage probability per subcarrier is 0.33×10^{-6} for 256-DAS in cell-1 which is much better than 256-DAS in cell-2, 8-DAS and 4-DAS.

4 CONCLUSION

The importance of OFDMA system is high throughput and low outage probability. The proposed efficient resource allocation algorithm is based on Distribution Antenna System (DAS) with 256-QAM modulation scheme. This proposed scheme is compared with various modulation scheme and different number of chunks in different cells at coherence bandwidth f_c =1.95MHz and f_c =0.49MHz.The average throughput per subcarrier and average outage probability are calculated with respect to the number of subcarrier per chunk at coherence bandwidth f_c = 1.95MHz and f_c = 0.49MHz. In this, as increasing the number of chunks the average throughput per subcarrier decreases but average outage probability increases. By comparing the results, the average throughput and average outage probability for 256-DAS in cell-1(number of chunks are 4) and 256-DAS in cell-2 (number of chunks are 5) is much better than 4-DAS and 8-DAS.

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