

# Modified Mean Greedy Allocation Algorithm in OFDMA System with Carrier Aggregation

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With increasing demand for faster access, then LTE-Advance system (LTE-A) is developed and released by the fourth generation (4G) mobile system. 3GPP introduced a new technology that is Carrier Aggregation (CA) to support wider transmission bandwidth and spectrum efficiency. With the CA system, every user can be scheduled on multiple carriers. Because of the difference in frequencies for each carrier, there are some differences too in fading and coverage for each carrier. This problem affects the performance of conventional resources allocation algorithm especially mean-greedy algorithm. Then a method to classify users and chunk according to the number of carriers that can be given to the user is proposed. This process is called user chunk grouping (UCG). This process is performed before the mean-greedy algorithm's process. Each user is grouped based on the characteristics of each component carrier fading experienced by the user. This scheme is expected to overcome the problem caused by CA system. Through simulation process, the UCG process can improve either fairness system or average throughput according to the ratio of user and bandwidth used in system.

**Keywords:** Carrier Aggregation, Mean-Greedy, User Grouping, LTE-

## 1. INTRODUCTION

Multiuser diversity is an outcome from free blurring channels crosswise over various clients. To enhance framework execution over remote channels, this multiuser diversity ought to be abused by designating the radio assets to clients appropriately as per the quick channel states of dynamic clients. These marvels are abused in LTE framework which utilizes OFDMA frameworks by dynamically allocating radio resources, for example, subcarrier to various clients each time transmission interval (TTI). This situation requires a adaptable channel management system to provide a dynamic and proportional channel capacity [1].

The most recent works of radio resource distributions for OFDMA frameworks are developed based on mean greedy-based algorithms since since they have low time multifaceted nature. Mean-Greedy algorithm is a modified greedy algorithm modification which sorts the user according to the average channel conditions experienced by each user.

In the transmission process, LTE systems uses OFDM techniques where one frequency band is divided into multiple subcarriers (chunk) to be allocated to the user. In LTE-A, Carrier Aggregation (CA) system was introduced. CA has introduced aggregation of non-contiguous spectrums in different spectrum bands to support wider

transmission bandwidth between the E-UTRAN NodeB (eNB) and the user equipment (UE). With the CA system, every user can be scheduled on multiple carriers, so one user may get resources from several different frequencies

Since the CA system is applied in LTE-A, the performance in radio resources (chunk) allocation is affected. Because of the difference in frequencies for each carrier, there are some differences too in fading and coverage for each carrier. Work [2] [3] [4] [5] propose scheduling scheme used in LTE systems with one carrier (without CA) so it is assumed all users will be scheduled on single carrier system. The study [6] [7] proved that with CA system in LTE-A, conventional proportional fair scheduling algorithm is not optimal because of the differences in fading characteristic and pathloss from each carrier, so that the grouping process is proposed. While in [8], grouping method is been modified for an mean greedy-based algorithm.

Then User Chunk Grouping (UCG) is proposed in [6] by partitioning all users into some group according to the number of carrier that they can be scheduled on. A group is contain some users who have the similar characteristic of pathloss propagation. The UCG process used in this paper is based on the Pathloss (PL) value suffered by all users on each of aggregated carriers. The PL value suffered by each user on all aggregated carriers are diverse due to the location different of all user. After all user is grouped, every chunk from each component carrier are distributed to each group of user before mean greedy chunk allocation is performed. In the previous work, there are no improvement between the original mean greedy and the UCG-mean greedy.

This paper try to optimize the usage of UCG process in mean-greedy algorithm by modifying several process in mean-greedy the algorithm to achieve performance improvement in the resource allocation algorithm.

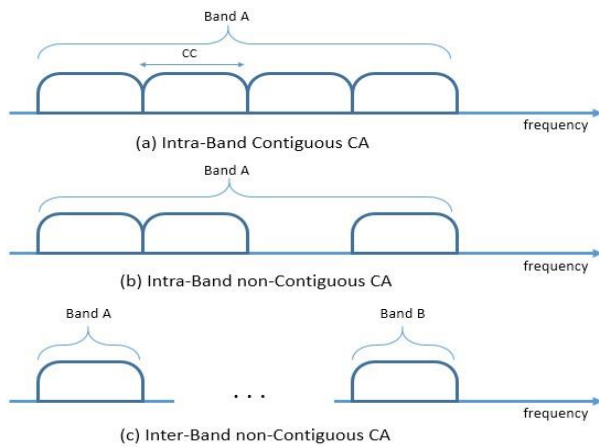


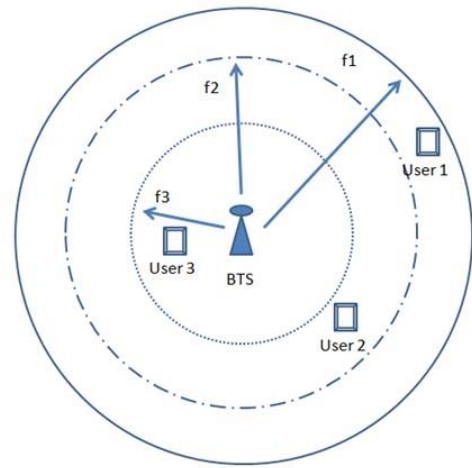
Fig.1. Carrier Aggregation System

We arrange this paper into five segments. Subsequent to presenting the foundation in area 1, we portray the model and plan in segment 2. In segment 3, the proposed algorithm are resolved and contrasted with the last works. The reenactments of the proposed algorithm are depicted in segment 4 and took after by conclusions in area 5.

**2. MODEL AND FORMULATION**

This works use a single cell system using non adjacent inter band aggregation scenario. There are 3 component carriers which are  $f_1, f_2$  and  $f_3$ , where  $f_1 < f_2 < f_3$ . Each carrier transmitted the same power  $P_T$ . Since the characteristic of fading on high frequency is bigger than the lower ones, it causes the coverage of  $f_2$  is smaller than  $f_1$  and the coverage of  $f_3$  is smaller than  $f_2$ . The cell structure model is shown in figure 2. User 1 is out of coverage of  $f_2$  and  $f_3$ , so it only could be scheduled on  $f_1$ . While user 2 is inside the coverage of  $f_1$  and  $f_2$ . User 3 could be scheduled on all carriers.

A cell consist of a base station with  $N$  users.  $L$  is the



A group which consist of aggregated carrier could be defined by [6]:

$$F = \{ \{ \dots \}, \{ \dots \} \} \quad (1)$$

UCG process is done by calculating the maximum value of path loss ( $PL$ ) of all users on each component carrier. A user to who has the smaller  $PL$  value than the pathloss threshold ( $PL_{th}$ ) could be specified into a certain group. The  $PL$  suffered by user  $i$  from each component carrier can be obtained using [6]:

$$PL_{i,c} = \{ \dots \} \quad (2)$$

where  $PL_{i,c}$  is the  $PL$  value from user  $i$  on carrier  $c$ . The element for group  $\Omega_c$  denoted by  $\Omega_c$

If  $\Omega_c = \Omega_c$  it means total number of carrier that can be scheduled on user  $i$  is  $j$ . So user could be divided into several groups [6]:

$$M_c = \{ \Omega_c = \Omega_c, 1 \leq \Omega_c \leq \Omega_c \} \quad (3)$$

The pathloss model used in this work is based on the Spatial Channel Model and  $PL_{i,c}$  could be determined as [6]:

$$PL_{i,c} = 58.83 + 37.6 \log_{10}(d_{i,c}) + 21 \log_{10}(f_c) \quad (4)$$

where  $d_{i,c}$  is the distance from user  $i$  to the base station. The coverage radius of  $c$  denoted by  $R_c$  could be calculated by [6]:

$$R_c = 58.83 + 37.6 \log_{10}(R_c) + 21 \log_{10}(f_c) \quad (5)$$

So, according to (1), it can be obtained that :

$$R_1 > R_2 > \dots > R_L \quad (6)$$

In the previous work, UCG process done by grouping the user according to the  $PL$  of each user to all component carriers. Then, the chunks from each carrier are divided to each group based on the total  $PL$  value. The total value of  $PL$  from all user in group  $\Omega_c$  on carrier  $c$  can be defined as [8]:

$$P_{\Omega_c} = \sum_{i \in \Omega_c} P_{i,c} \quad (7)$$

number of component carrier aggregated. Each component carrier has the same bandwidth.  $V$  is the total of chunk on each carrier. With equal power allocation (EPA), each chunk  $z$  has transmitted power  $p(z) = P_T / V$ .

Fig.2. Single Cell System

where  $M$  is the number of total member group  $M$

Since the number of chunk from each carrier is  $V$ , it means that the number of chunk divided from carrier  $M$  on each group must not greater than  $V$ . The number of

chunk obtained by group  $G$  from carrier  $C$  could be calculated by [8]:

$$C_{G,C} = \lfloor \frac{B_C}{T_{G,C}} \cdot \frac{1}{\sum_{i \in G} SNR_{i,z}} \rfloor \quad (8)$$

$$\sum_{G \in \mathcal{G}} C_{G,C} \leq V \quad (9)$$

So, the total number of chunk obtained by group  $G$  from all carrier that can be scheduled on is defined by [8]:

$$X_G = \sum_{C \in \mathcal{C}} C_{G,C} \quad (10)$$

The chunk allocation is performed on each  $G$ . In this state, each user group has specific number of chunk of carrier that can be scheduled based on definition 4. The group of chunk on each group of user group is called Group-Chunk-User (GCU).

Each GCU contain the signal to noise ratio (SNR) of user -  $i$  on chunk -  $z$  which is given by [8]:

$$SNR_{i,z} = \frac{P_i}{N_0} \cdot \frac{1}{L_{i,z}} \quad (11)$$

$L_{i,z}$  is the total loss propagation and  $s$  is the scheduling slot which is slot within one time transmission interval (TTI).

After all SNR of all users on all chunks have been known, chunk allocation is conducted on each GCU. SNR of all chunks on each user are averaged and sort them from the lowest. A user on each GCU who has the lowest SNR choose the best chunk. It called UCG-MG algorithm.

### 3. PROPOSED ALGORITHM

The case in the system is received signal samples taken during the transmission and when the eNB makes correct decisions which occur with high probability in a well designed [9]. The main works is to modify the mean greedy algorithm in order to improve the usage of UCG process. The proposed algorithm is called UCG-modified MG algorithm (UCG-mMG). This algorithm is divided into 2 main process. The UCG process and the mMG algorithm.

For the initialization, there are several steps [8]:

1. All user measured the conditions of all chunk, valued by the SNR.
2. Calculate the average of chunk SNR on each user
3. User is sorted according to the average SNR. from the lowest average SNR to the largest average SNR.
4. The output from this process are the user order table that will be used in the allocation algorithm.

2. All users are divided into specific group using (2) and (3)
3. A GCU are formed for each component carrier by distributing all chunks from each component carrier

to user group which belong to that carrier based on

definition 3 and definition 4. Each GCU has specific number of chunk from the carrier that can be

scheduled on.

After the UCG process, there are several GCU according to the total number of component carrier. The mMG algorithm will performed in each GCU independently. In this paper, there are 2 type of mMG that performed on each GCU and will be compared with the original MG algorithm.

The first mMG algorithm (mMG-1) processes are described below :

1. Each GCU is divided into a  $k \times k$  matrix
2. Each user select the chunk with the best condition alternately in the GCU the user belongs to according to the user order table form initialization process.
3. Process number 2 is repeated until all chunks is allocated
4. If there are remaining unused chunks because of the number of chunk in the GCU is not multiple of  $k$ , the unused chunks are allocated to the user according to the order of the user.

The second modification (mMG-2) does not divide each GCU into a  $k \times k$  matrix like mMG-1. The mMG-2 algorithm processes are described below :

1. Each user select the chunk with the best condition alternately according to the user order table form initialization process.
2. Process number 1 is repeated until all chunks is allocated.

After the allocation algorithm is performed, average user throughput and fairness system are calculated by [8]:

$$R_T = \frac{B}{\sum_{C \in \mathcal{C}} \sum_{G \in \mathcal{G}} C_{G,C}} \cdot \sum_{G \in \mathcal{G}} \sum_{i \in G} SNR_{i,z} \cdot (1 + \alpha) \quad (12)$$

where  $R_T$  is the throughput system and  $S_{i,z}$  is chunk assignment index.  $B$  is bandwidth system and  $SNR_{i,z}$  is SNR of user- $i$  on chunk- $z$ . The fairness is system is calculated based on :

$$F = \frac{\sum_{i \in \mathcal{U}} R_i^2}{\sum_{i \in \mathcal{U}} R_i} \quad (13)$$

In the previous works, user is sorted after the UCG process. In this paper, this process is done before the UCG

process, because this will measured overall conditions of each user.

After the initialization process, the UCG process is executed. The UCG process can be described as follow :



1. For all users, calculate the  $\alpha_k$  of all aggregated component carriers according to (4).

After the performance parameters are calculated, UCG-mMG-1 and UCG-mMG-2 are compared to the original mean greedy algorithm to analyze the performance of each modified algorithm.

#### 4. SIMULATION AND RESULT

In order to evaluate the proposed scheme, the computer simulation is performed using montecarlo method. The number of simulation trial is equal to the

number of time transmission interval (TTI).

The simulation is conducted on downlink path of LTE-Advanced with non-contiguous interband carrier aggregation. The simulation is done by varying the number of users from 50 to 150 users within a cell. The performances of the proposed schemes is compared with mean greedy algorithm (MG) which does not use the UCG process before chunk allocation. The average throughput and fairness index of each schemes are

compared and evaluated. The other simulation parameters are listed in Table I.

Table.1. Simulation Parameters [8]

Parameter	Value
Bandwidth per carrier	10 Mhz and 20 Mhz
Number of chunk per carrier	50 chunks and 100 chunks
TTI	200 TTI
Cell radius	250 meter
Cell Layout	Single cell
Component carrier frequency	700 Mhz, 900 Mhz, 1800 Mhz
Chunk bandwidth	180 kHz
Propagation Model	Spatial Model Channel, Rayleigh channel
Gain eNB	18 dBi
Gain UE	0 dBi
Noise Figure	7 dB
eNB transmitted power	40 Watt (46 dBm)
Penetration Loss	20 dB
Number of user	50 - 150

The first simulation is conducted in the system with 10 MHz bandwidth for each component carrier. The results are shown in figure 3 and figure 4. The graph indicate that the proposed algorithms (UCG-mMG-1 and UCG-mMG-2) have slightly better fairness than the original MG algorithm. However, the proposed algorithm average throughput's is decreased.

The second simulation is conducted in the system with 20 MHz bandwidth for each component carrier. The results are shown in figure 5 and figure 6. The graph indicate that the proposed algorithms (UCG-mMG-1 and UCG-mMG-2) have a lot better fairness than the original MG algorithm. However, the proposed algorithm average throughput's is decreased

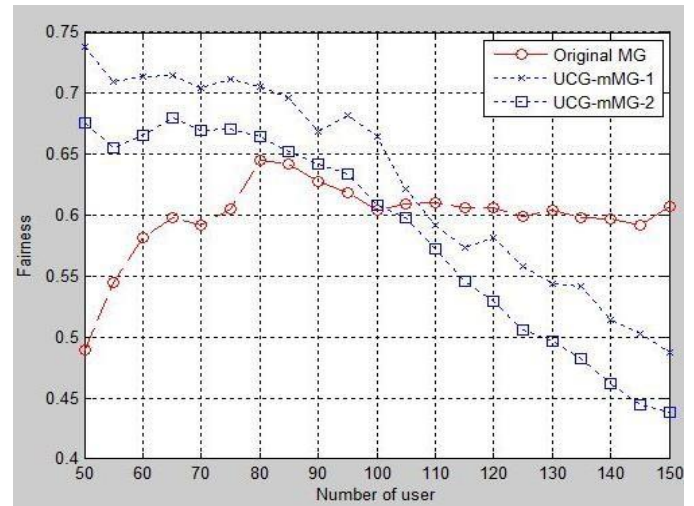


Fig.3. Fairness System on 10 MHz Bandwidth

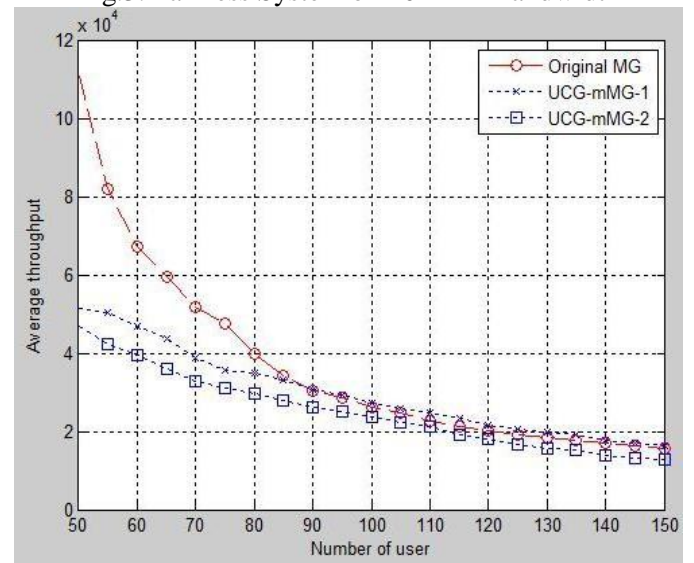


Fig.4. Average Throughput System on 10 MHz Bandwidth

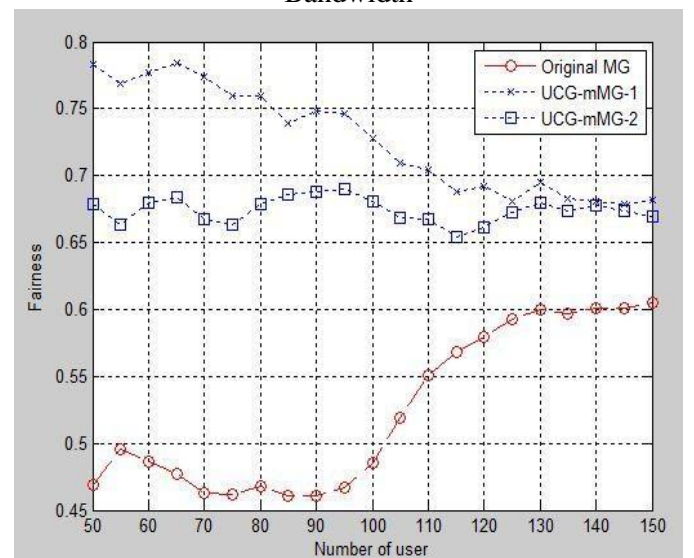


Fig.5. Fairness System on 20 MHz Bandwidth



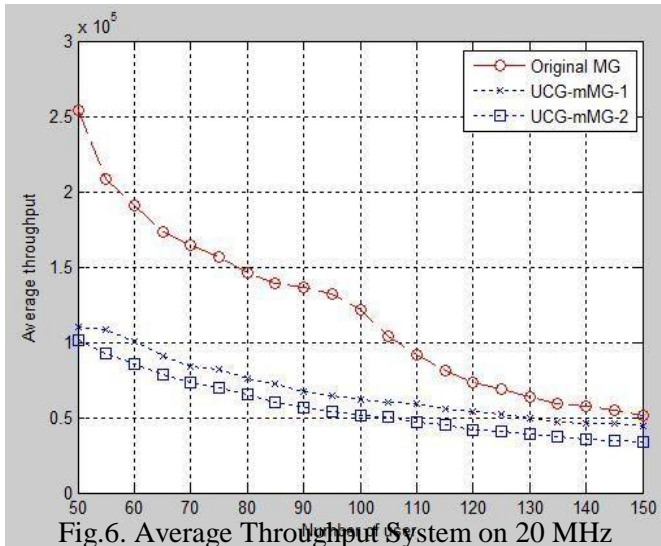


Fig.6. Average Throughput System on 20 MHz

This improvements happen because the initialization process executed before the UCG process. This process can keeps the balances in fairness system because user with the worst channel conditions get the chance to select the best chunk.

UCG process gives the user in the cell edge some chunks from the lowest frequency that has the smallest fading characteristic, so the signal quality is good. But UCG process makes the average user throughput decreases because UCG allocates the best conditions chunk to the cell edges user which can not maximizes the throughput system.

Table.2. The Simulation Results

Bandwidth	Algoritihm	Average Fairness	Average Throughput (bps)
10 MHz	Mean Greedy	58.61%	36717.87
	UCG-mMG-1	62.98%	29877.11
	UCG-mMG-2	59.54%	25164.13
20 MHz	Mean Greedy	52.42%	120314.21
	UCG-mMG-1	72.67%	68157.44
	UCG-mMG-2	67.40%	56793.08

5. CONCLUSIONS

In this work, a modified mean greedy algorithm with UCG process is evaluated and proposed This scheme is applied on LTE-A system with carrier aggregation in OFDMA-based technology. The proposed algorithm shows there are some improvement in fairness system in overall, but there are some reduction in average system throughput. This results is caused by the UCG process who give the best chunk to the user in the cell edges. This allocation can keep the fairness system in balance, but can't maximize the throughput value.

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