User-Order Chunk Allocation using Priority in OFDMA Systems

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Multi carrier system is expected to be able to offer high data rate, to support a large number of users and to ensure the fulfillment of quality of service (QOS) requirements. The demands of subscriber on data services with the explosive development of traffic such as Internet, video interactive, email, gaming, and so forth from users. To support these subscriber demands and promising QOS, in multi carrier system, scheduling algorithm priority scheme which consists of three main processes of scheduling, radio resources management, packet scheduling and priority schemes is implemented. The combination of User Order algorithm and QoS Class Identifier (QCI-Order) using weighting factor for user priority with Promethee method to group and evaluate the users will be done for all user in each Time Trigger Interval (TTI). Measurements of total average spectral efficiency and fairness for each number of users in the normal and overload condition resulted in the improvement of fairness index has more 8 percents than previous algorithm.

Keywords: Scheduling Priority, Multi Carrier system, QCI, Promethee

1. INTRODUCTION

Multi carrier system is expected to be able to offer high data rate, to support a large number of subscribers and to ensure the fulfillment of quality of service (QoS) requirements[11,12]. Based on 3GPP TS 36.300[1], VoIP call, Video call, Online Gaming and video streaming are included in Guaranteed Bit Rate (GBR) services. Meanwhile, the Non-GBR includes the services of IMS signaling, email, ftp, interactive gaming. To Guarantee user's QoS, user priority should be differentiated for user categories based on the run bearer weight.

On Arfianto Fahmi's[2] paper, a research has been conducted related to radio resource allocation on the uplink technology of 4G Long Term Evolution (LTE), by using Promethee method to evaluate and determine the best UE and Chunk pair. On Moszes Angga's[3] paper, a research has been conducted related to Priority Scheduling on the Downlink technology of WiMAX with Knop and Humblet / Multi-Carrier Proportional Fair (K&H/MPF) algorithms as its Radio Resource allocation, by giving priority of high data rate allocation to the user with the highest QoS class and then to the lowest. On Chandra's[4] paper, a research has been conducted related to user classification based on services in terms of its traffic characteristics. On Fayyesal Bendoud's[5] paper, a comparison has been done between Proportional Fair scheduling and Round Robin for Downlink scheduling. On Carlos A. Astudillo's[9] paper, an uplink packet scheduling has been done with QoS guarantee i.e. Z-Based QoS Scheduler (ZBQoS) method, Scheduler Z-Based QoS by dividing the scheduling process into the time domain for QoS and the frequency domain for channel quality, but its Fairness is weak. On Radhia khdhir's[8] paper, a packet scheduling has been done with the differences in GBR and non-GBR traffics are based on the size of packet delay and its delay budget as the components of allocation priority. On P.Varzakas[13] paper, the main work is how to optimize number of subs carrier of a celluler OFDM system in a Rayleigh fading environment to maximization of the achieved spectral efficiency.

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In this paper, a novel expression for the optimal number of chunk allocation based on spectral efficiency and QoS Class Identifier (QCI-Order) using weighting factor for user priority with Promethee method.

2. PROBLEM FORMULATION

2.1 Promethee Method

The Promethee method is a sorting method which is generally used in a variety of research disciplines including industrial engineering and operation research. The advantages of this method is that it can ranks the multidimensional alternatives by considering the criteria from all dimensi[2,6]. Promethee can be described as follows :

Let $a, b \in A$, and let :

$$\begin{cases} \pi(a,b) = \sum_{j=1}^{J} f_j(a,b) w_j \\ \pi(b,a) = \sum_{j=1}^{J} f_j(b,a) w_j \end{cases} \quad (1)$$

Where :

$$f_j(a,b) = F_j[g_j(a)] - F_j[g_j(b)]$$
$$f_j(b,a) = F_j[g_j(b)] - F_j[g_j(a)] \quad (2)$$

$\pi(a,b)$ is expresses to which degree a is preferred to b over all criteria[3].

$\pi(b,a)$ is expresses to which degree b is preferred to a. w_j is weighting factor of criteria-j.

These function give the preferences of a over b and b over a for observed deviations between their evaluation function $F_j(.)$ on criteria $g_j(.)$. at this step is determined a Function and criteria to evaluate.

2.2 User-Order Scheduling

User-Order Allocation allocates chunk to each user by using the promethee method.

The matrix of user's spectral efficiency for every chunk is calculated by using the Channel State Information (CSI) data. After that, a function with the criteria of spectral efficiency values among users is determined by using the Promethee method. This can be denoted as follow[3]:

$$\pi(i,i') = \sum_{j=1}^{C} (F_j[g_j(i)] - F_j[g_j(i')]) w_j \ ,$$
$$\forall i \neq i', i, i' \in K$$
$$= \sum_{j=1}^{C} (r_{j,i} - r_{j,i'}) w_j \quad (3)$$

$r_{j,i}$ is the spectral efficiency user -i on chunk -j. w_j is weighting factor of the spectral efficiency on chunk -j expressing the priority of it. Since the priority of spectral efficiency on all chunks are same, the weighting factor are also the same[3]. So it becomes:

$$\pi(i,i') = \bar{r}_i - \bar{r}_{i'} \quad (4)$$

Where $\bar{r}_i$ is the spectral efficiency average over C chunks on user –i.

The problem found is the weight of each user is not the same among the bearers, so that it is necessary to be distinguished based on each bearer.

3.THE PROPOSED ALGORITHM

3.1 Radio Resource Allocation

The process of chunk allocation priority consists of three stages of scheduling. The first stage is the matriculation of user's spectral efficiency for every chunk, by calculating all SE scores for all users in all chunks, then a matrix is obtained that contains SE score for all pairs of chunk user. The second stage is the matriculation of each user based on each QCI weight. Then the SE score of each user is evaluated by using Promethee method. By comparing the SE score of certain chunk c when used in the user k for all K. By comparing the SE score of certain chunk c when used in the user k for all K. Then a sorting is done by using negative outranking to get certain user k that is the most prioritized to be scheduled. The third stage is to do comparison with each QoS user and the QoS bearer that is used until certain score limit is achieved.

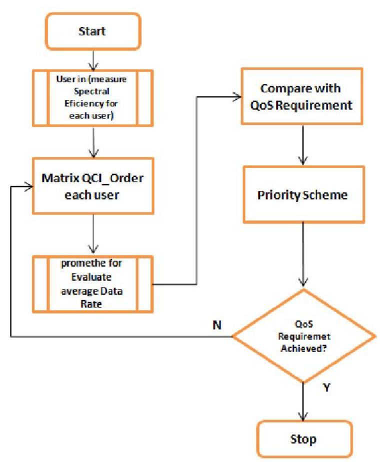

Fig.1. QCI-User Order Schedulling Algorithm

In this study Radio Resource Allocation is examined by taking information on Spectral Efficiency of each user from CSI for each pair of Chunk user. Then an evaluation is done by using the criteria of QCI bearer and Spectral Efficiency of each user. Then it is prioritized scheduling for user with the highest QCI. If there is the same QCI, then the score of its spectral efficiency will be reviewed.

3.2 Model QCI-User Order Scheduling

In the QCI-Order, the weight of each user is reviewed by QCI requirement from each user. The following is the system model of QCI-User Order scheduling:

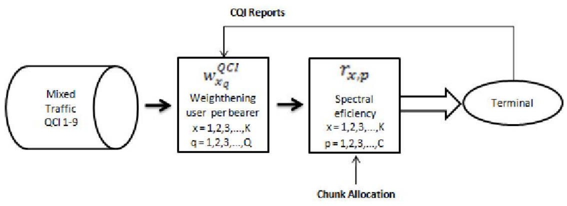

Fig.2. The System Model of QCI-User Order

The system model of QCI-User Order consists of three stages, namely:

A. Measuring the score of Spectral Efficiency of each Pair of User-Chunk

Spectral Efficiency is defined as the data rate per unit channel bandwidth for a specified average transitted power and a fixed bit-error rate (BER) value[13]. Measuring the score of Spectral Efficiency of each pair of Chunk user by using the following formula:

$$r_{ck} = \frac{R_{ck}}{b} \qquad (5)$$

where:

$$R_{ck} = b\ log_2\left[1 + \frac{\gamma_{ck}}{\Gamma}\right] \qquad (6)$$

r_{ck} is the Spectral Efficiency user –*k* on chunk –*c*.
R_{ck} is the data rate user –*k* on chunk –*c*.
b is the bandwidth of chunk by the formula $b = \frac{B}{C}$
where : B is Bandwidth of system and C is number of Chunk.
γ_{ck} is Signal Noise Ratio (SNR) user –*k* on chunk –*c*.
Γ is SNR Gap, it can be formulated as follow[2]:

$$\Gamma = \frac{ln(5BER)}{1.5} \qquad (7)$$

γ_{ck} is affected by γ_{nk} or value of SNR user -*k* on subcarrier –*n*[2], as follow:

$$\gamma_{c,k} = \left(\frac{1}{\frac{1}{n_c}\sum_{n=in_c+1}^{in_c+n_c}\frac{\gamma_{n,k}}{\gamma_{n,k}+1}} - 1\right)^{-1} \qquad (8)$$

γ_{nk} is affected by Power subs carrier allocation, Chanel Gain, and Noise.
It can be formulated as follow [2,7] :

$$\gamma_{nk} = P_{nk}.\frac{h_{nk}}{\sigma_n^2} \qquad (9)$$

Or it can also be written as follows:

$$\gamma_{nk} = P_{nk}.CNR_{nk} \qquad (10)$$

Where:

$$CNR_{nk} = \frac{H_{nk}}{\sigma_n^2} \qquad (11)$$

CNR will be affected by Rayleigh Fading R_{nk}, propagation loss L_p, path loss exponent δ, distance UE to e-Node B d_k, lognormal shadowing ε_{nk}, Noise Spectral Density N_o and bandwidth per subs carrier B.

$$CNR_{n,k}[dB] = 10logR_{n,k} - L_p - 10\delta logd_k - \varepsilon_{n,k} - N_o.B \qquad (12)$$

B. QCI Weighting Priority

By calculating the weight of each QCI class, it is obtained the following table:

Tabel.1. QCI Weighting per bearer

QCI	priority	Weighting Factor
5	1	0.2
1	2	0.18
3	3	0.16
2	4	0.13
4	5	0.11
6	6	0.09
7	7	0.07
8	8	0.04
9	9	0.02

As a result, it is obtained the weight of QCI_Order of each user :

$$w_{x_q}^{QCI} = [0.20; 0.18; 0.16; 0.13; 0.11.0.09; 0.07; 0.04; 0.02] \qquad (13)$$

C. Evaluating the Score of Spectral Efficiency of each Pair of Chunk User

The evaluation function of the score of spectral efficiency, where user $x \neq$ user x'.

$$\pi(x,x') = \sum_{p=1}^{C}\left(F_p[g_p(a)] - F_p[g_p(a')]\right)w_{x_q}^{QCI},$$
$$\forall x \neq x', x, x' \epsilon K$$

$$= \sum_{p=1}^{C}\left(r_{x,p} - r_{x',p}\right)w_{x_q}^{QCI} \qquad (14)$$

$r_{x,p}$ is the spectral efficiency of user -*x* on chunk -*p* .

$$w_{x_q}^{QCI} = \begin{cases} QCI\ (1-4), for\ GBR \\ QCI\ (5-9), for\ non-GBR \end{cases} \qquad (15)$$

$w_{x_q}^{QCI}$ is the weight of user -*x* on QCI bearer -*q*.

$\pi(x, x')$ is expressing which degree user -*x* is preferred to user -*x'* for spectral efficiency criteria. And this is done for all user –*x*, so that it is obtained the comparison table of level score among all –*x*.
The results of the classification table above then are sorted by calculating the negative outranking in all user *x'* to *x*, so that it is obtained the aggregate score of user *x*. This is done again for all score of *x*. the negative outranking can be expressed by the following formula:

$$\partial^-(x) = \frac{1}{C-1}\sum_{j\epsilon C}\pi(j, x),\ \forall x \neq x' \epsilon K \quad (16)$$

where $\partial^-(x)$ describes the aggregate score of *x* to all score of *j* (or another score of *x'*) to all user *K*. Then it is obtained a table that consists of all aggregate score from each *x* to all users. Determination of optimal user *x* and chunk *c*.
To determine the prioritized user *x*, argument max is used to take the score of negative outranking that gives the biggest score. This can be expressed by the following formula:

$$x = \arg max(\partial^-(x)), x = 1,2, \dots, K \quad (17)$$

Furthermore, a chunk allocated to user –*x* is determined by searching a chunk which gives the highest spectral efficiency on user –*x*. this is also used in[2,]

$$c = \arg max(r_{x,c}), c = 1,2, \dots C \quad (18)$$

4. EXPERIMENTAL RESULT

The test to examine the algorithm scheme will be carried out under the condition of one e-NodeB with 65 degrees Horizontal Beam width (HBW) sectoral antenna with 16 dBi Gain (G). The test is carried out in the 850 Mhz frequency with 5 Mhz Bandwidth, 15 khz subcarrier frequency and 1 chunk that consists of 12 subcarriers[10] with 180 khz Bandwith. The simulation uses the software of MATLAB 8.0.0.783 (R2012b). The technology used is FDD with the capacity of 25 resource blocks. The evaluation will be done by using five to fifty users with the step size by five users. The test is carried out with an assumption that the condition of Power Chunk is the same for every chunk, with the distance of user to eNodeB is random.

The number of QCI bearer used is 9, according to the standards of 3GPP[1], with the weight that is in accordance with the table 1. Random user is also generated for each TTI. The CSI is known perfectly by eNode-B in each TTI with the number of TTI used is 5000.

For SE matrix with the size of n x m, n is the number of user and m is the number of available chunk. It is assumed that there is always C chunk available for K user. From the matrix input, it will be calculated the score of SE for each pair of chunk user by using the formula $r_{ck} = \frac{R_{ck}}{b}$.

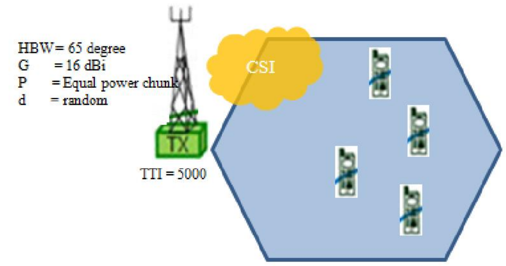

Fig.3. The Evaluation of QCI User

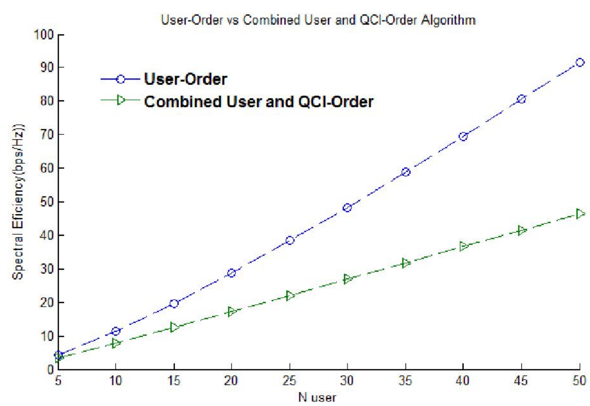

Fig.4.Sum average of spectral efficiency versus the number of users

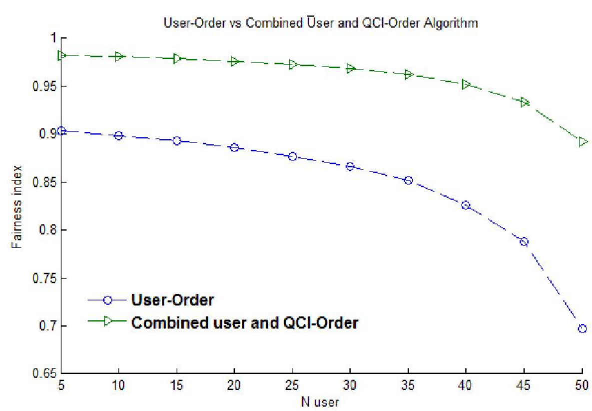

Fig.5.The average of fairness index versus the number of users

5. CONCLUSIONS

Combined QCI-User Order algorithm gives a higher score of Fairness Index has more 8 percents than User Order algorithm. However, the score of Spectral Efficiency of QCI-User Order is not much better than User Order algorithm, with a range of observations for 5 to 50 users.

QCI-User Order algorithm has a better fairness index because it gives opportunity for all users based on QCI and the average score of SE. Meanwhile, user order algorithm only considers the score of SE or the effect of channel condition.

ACKNOWLEDGMENTS

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