Resource Allocation Optimization for Orthogonal Frequency Division Multiplexing Access using Modified Utility Function

Kon Kim*

Faculty of Communication, Kim Chaek University of Technology, Pyongyang 999093, Democratic People's Republic of Korea

***Corresponding author**

DOI: https://doi.org/10.51583/IJLTEMAS.2025.1411000028

Received: 10 November 2025; Accepted: 20 November 2025; Published: 03 December 2025

ABSTRACT

In this paper, we propose an optimal method for resource allocation in OFDMA (Orthogonal Frequency Division Multiplexing Access) system. The utility function is used to balance the efficiency and fairness of wireless resource allocation. We analyze the mathematical property of resource allocation by modified utility function. We develop optimal algorithm for dynamic subcarrier assignment and adaptive power allocation based on modified utility function, and demonstrate the convergence properties of optimization. Simulation results show that the proposed method provides the effective tradeoff between fairness and efficiency in radio resource allocation.

Keywords: OFDMA, Utility Function, Fairness and efficiency, Adaptive power allocation and subcarrier assignment.

INTRODUCTION

OFDMA is a kind of multiple access technology. It has overcome the disadvantage of OFDM-TDMA which allocates all resource to a single user at certain time. The principle of OFDMA is that it can vary the resource allocation according to some conditions containing path condition [1-10].

Impulse response of a general time-varying multi-path channel can be represented as

$$h(t,\tau)=\sum_{i=1}^{I}\gamma_i(t)\delta(\tau-\tau_i) \qquad (1)$$

And transfer function is

$$H(f,t)=\int_{-\infty}^{+\infty}h(t,\tau)e^{-j2\pi f\tau}d\tau \qquad (2)$$

It is assumed that the channel fading rate is slow enough so that the frequency response does not change during an OFDM symbol. The condition of channel can be based on signal nose ratio function.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue XI, November 2025

$$\rho(f,t) = \frac{|H(f,t)|^2}{N(f,t)} \quad (3)$$

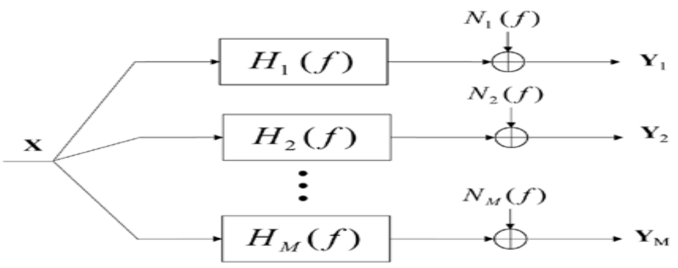
Using adaptive modulation, the transmitter can send higher data rates over the subcarriers with better channel conditions to improve throughput and simultaneously ensure an acceptable BER in all subcarriers.

And the achievable throughput can be expressed as

$$c(f,t) = \log_2(1+\frac{\beta p(f,t)|H(f,t)|^2}{N(f,t)}) = \log_2(1+\beta p(f,t)\rho(f,t)) \quad (4)$$

System consisted of M users is shown in Fig.1.

Fig. 1. System of M users



And the m[th] user's throughput is

$$c_m(f,t) = \log_2(1+\frac{\beta p(f,t)|H_m(f,t)|^2}{N_m(f)}) = \log_2(1+\beta p(f,t)\rho_m(f,t)) \quad (5)$$

And the rate of m[th] user is

$$r_m(t) = \int_{D_m} c_m(f,t)df = \int_{D_m} \log_2[1+\beta p(f,t)\rho_m(f,t)]df \quad (6)$$

And then the target is to maximize the entire rate sum of users in some essays. That is

$$\max_{D,p(f)} \sum_{m=1}^{M} r_m \quad (7)$$

To solve this problem a lot of approaches have implemented.[1],[4]

But the target is emphasized on maximizing the entire rate sum, so this problem has disadvantage of unfairness among users. To overcome this shortcoming weighted-sum method is adopted.

$$\max_{D,p(f)} \sum_{m=1}^{M} w_m r_m \quad (8)$$

But this method is not as good as utility function method.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue XI, November 2025

The approaches used to solve the problem of OFDMA resource allocation formulated as rate sum or weighted sum are shown in Refs. [1]-[10].

Table 1 shows the approaches used in the resource allocation.

Table 1. Approaches used in resource allocation

Approach	Terminate at	Complexity
Lagrangian method	None	$O(MK)$
SQP	Iteration	$O(K^3)$
Simulated Annealing	Condition Satisfaction	$O(M^3K^3L^3)$
Genetic Algorithm	Generation	$O(1.65\times 2^{0.21K}\times MK)$
Branch and bound method	None	2^{MKL}

As can be seen from Table 1, every approach has own character and advantage and disadvantage. First the accuracy of approach simulated annealing and genetic algorithm cannot get the exact results. And the complexity is lowest in Lagrangian function.

On the other hand, the formulation of problem is most adjectival in utility function method. So we proposed three problems in this paper.

First is to analyze the mathematical property of resource allocation by modified utility function,Second is to develop optimal algorithm for the resource allocation in OFDMA system,Third is to simulate the proposed method and verify the efficiency of the system.

METHODS

Modified utility function

Utility functions are used to quantify the benefit of usage of certain resources. And the target function using Utility function is

$$\max_{D,p(f)} \frac{1}{M}\sum_{\mathcal{M}} U_m(r_m) \qquad (9)$$

For the global optimality, Eq. (9) must be a concave function.

If all $U_m(r_m)$ are concave functions, then the objective function(9) is also a concave function. But in reality, all $U_m(r_m)$ are not concave functions.

So utility function is modified $U(r)$ into $\tilde{U}(r)$ as follows.

$$\tilde{U}(r) = \begin{cases} U(r) & r \ge r_{\mathrm{crt}} \\ 0 & 0 \le r < r_{\mathrm{crt}} \end{cases} \qquad (10)$$

Then $\tilde{U}(r)$ is concave in $[0,+\infty)$. All functions concave in $[r_{\mathrm{crt}},+\infty)$ can be modified into $\tilde{U}(r)$.

As the objective function is concave, there is a unique global maximum solution to the optimization problems.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue XI, November 2025

Continuous rate optimization

Let ρ_m and K be mth user's SNR and the number of available subcarriers, respectively. ρ_m can be described by

$$\rho_m = (\rho_{m,1}, \rho_{m,2}, \cdots, \rho_{m,K}) \qquad (11)$$

where $\rho_{m,k}$ is mth user's SNR at kth subcarrier.

A transmission power p_k at kth subcarrier can be expressed as follows.

$$p_k = (p_{1,k}, p_{2,k}, \cdots p_{M,k}) \qquad (12)$$

where $p_{m,k}$ is a transmission power at kth subcarrier allocated to the mth user.

Define D_i as the frequency set assigned to user i. Then

$$D_m \bigcap D_n = \varnothing, \quad \forall m, n \in \mathcal{M}, m \neq n$$

where $\varnothing$ denotes an empty set.

The transmission throughput of mth user at kth subcarrier can be expressed as

$$r_{m,k} = \log(1 + \beta p_{m,k} \rho_{m,k}) \Delta f \quad . \qquad (13)$$

where Δf is the bandwidth of the subcarrier.

Then optimization problem can be regarded as

$$\max U = \max_p \frac{1}{M} \sum_{m=1}^{M} U_m \left(\sum_{k=1}^{K} r_{m,k}(p_{m,k} \rho_{m,k}) \right) \qquad (14)$$

subject to

$$\sum_{m=1}^{M} \sum_{k=1}^{K} p_{m,k} \leq \overline{P} .$$

where $\overline{P}$ is the maximum transmission power of the transmitter.

Using the Lagrangian method, the above optimization problem with the power constraint becomes to maximize

$$L(p, \lambda) = \frac{1}{M} \sum_{m=1}^{M} U_m \left(\sum_{k=1}^{K} r_{m,k}(p_{m,k} \rho_{m,k}) \right) + \lambda \left(\overline{P} - \sum_{m=1}^{M} \sum_{k=1}^{K} p_{m,k} \right) . \qquad (15)$$

Then the dual problem for (15) is defined as

$$g^* = \min_{\lambda \geq 0} \theta(\lambda) . \qquad (16)$$

where

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue XI, November 2025

$$\theta(\lambda) = \max_{p \in P} L(p,\lambda) = \lambda \overline{P} + \max_{p} \frac{1}{M} \sum_{m=1}^{M} U_m \left(\sum_{k=1}^{K} r_{m,k}(p_{m,k}\rho_{m,k}) - \lambda p_{m,k} \right) \quad (17)$$

As the subcarrier assignment is independent of the power allocation,

$$\theta(\lambda) = \lambda \overline{P} + \sum_{k=1}^{K} \max_{p_k} \frac{1}{M} \sum_{m=1}^{M} U_m (r_{m,k}(p_{m,k}\rho_{m,k}) - \lambda p_{m,k}). \quad (18)$$

As a subcarrier is not shared by two or more users and the channel gain is not independent of subcarriers but distributed ideally

$$\theta(\lambda) = \lambda \overline{P} + K \max_{M} \frac{1}{M} (\max_{p_{m,k \geq 0}} (U_m (r_{m,k}(p_{m,k}\rho_{m,k}) - \lambda p_{m,k}))) . \quad (19)$$

In (19) $\max_{p_{m,k}} (U_m (r_{m,k}(p_{m,k}\rho_{m,k}) - \lambda p_{m,k}))$ satisfies the following equation for the optimal power allocation.

$$p^{*}_{m,k}(\lambda) = \left[\frac{1}{\rho_{0,m}(\lambda)} - \frac{1}{\rho_{m,k}} \right]^{+} \quad (20)$$

Where $\rho_{0,m}(\lambda) = \dfrac{\lambda}{U'_m(r^{*}_{m,k})}$. (21)

By (19) and (20), (16) can be described as follows.

$$g^{*} = \min_{\lambda \geq 0} [\lambda \overline{P} + K g_k(\rho_m, \lambda)] \quad (22)$$

where $g_k(\rho_m, \lambda) = \max_{M} [g_{m,k}(\rho_{m,k}, \lambda)]$ (23)

$$g_{m,k}(\rho_{m,k}, \lambda) = U'_m(r^{*}_{m,k}) r_{m,k}(p^{*}_{m,k}(\lambda)\rho_{m,k}) - \lambda p^{*}_{m,k}(\lambda) \quad (24)$$

Let I be the number of the function evaluations to converge.

If $\lambda^{*} \in [\lambda_{\min}, \lambda_{\max}]$,

$$I = \left[\frac{\ln(\varepsilon / (\lambda_{\min} - \lambda_{\max}))}{\log(0.618)} + 1 \right] \quad (25)$$

where ε is an allowable error.

If ε is small enough to satisfy the power constraint, i.e $\sum_{K} p^{*}_{m,k} = \overline{P}$,

$$\lambda_{\min} = \frac{\ln 2}{K \min_{M} U'_m(r^{*}_{m,k})} \left(\overline{P} + \sum_{K} \max_{m} \frac{1}{\rho_{m,k}} \right) \leq \lambda^{*} \leq \frac{K}{\overline{P} \ln 2} \max_{m} U'_m(r^{*}_{m,k}) = \lambda_{\max} . \quad (26)$$

Then $\overline{P} = \sum_{K} \left[\dfrac{U'_m(r^{*}_{m,k})}{\lambda^{*} \ln 2} - \dfrac{1}{\rho_{m,k}} \right]^{+}$ (27)

INTERNATIONAL JOURNAL OF LATEST TECHNOLOGY IN ENGINEERING, MANAGEMENT & APPLIED SCIENCE (IJLTEMAS)
ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue XI, November 2025

$$\geq \sum_K \min_m \left[\frac{U_m^{'}(r_{m,k}^*)}{\lambda^* \ln 2} - \frac{1}{\rho_{m,k}} \right]^+ \quad (28)$$

$$\geq \sum_K \left[\frac{\min_m U_m^{'}(r_{m,k}^*)}{\lambda^* \ln 2} - \max_m \frac{1}{\rho_{m,k}} \right]^+ \quad (29)$$

$$= K \frac{\min_m U_m^{'}(r_{m,k}^*)}{\lambda^* \ln 2} - \sum_K \max_m \frac{1}{\rho_{m,k}} \quad (30)$$

$$\lambda^* \geq \frac{\ln 2}{K \min_m U_m^{'}(r_{m,k}^*)} \left(\overline{P} + \sum_K \max_m \frac{1}{\rho_{m,k}} \right) \quad (31)$$

Also

$$\overline{P} = \sum_K \left[\frac{U_m^{'}(r_{m,k}^*)}{\lambda^* \ln 2} - \frac{1}{\rho_{m,k}} \right]^+ \quad (32)$$

$$\leq \sum_K \max_m \left[\frac{U_m^{'}(r_{m,k}^*)}{\lambda^* \ln 2} - \frac{1}{\rho_{m,k}} \right]^+ \quad (33)$$

$$\leq \frac{K}{\lambda^* \ln 2} \max_m U_m^{'}(r_{m,k}^*) \quad (34)$$

$$\lambda^* \leq \frac{K}{\overline{P} \ln 2} \max_m U_m^{'}(r_{m,k}^*) \quad (35)$$

Then, from (31) and (25), we found (26) is satisfied.

After getting λ^*, the optimal multiplier λ^* determines the user selection and power allocation per subcarrier k:

$$m_k^* = \arg\max_m \{U_m^{'}(r_{m,k}^*) r_{m,k}(\tilde{p}_{m,k}(\lambda^*)\rho_{m,k}) - \lambda^* \tilde{p}_{m,k}(\lambda^*)\} \quad (36)$$

$$p_{m,k}^* = \tilde{p}_{m,k}(\lambda^*) 1(m = m_k^*) \quad (37)$$

where $1(x) = \begin{cases} 1, & x \text{ is true} \\ 0, & x \text{ is false} \end{cases}$. (38)

Note, however, that it is possible that the sum of the candidate power allocation vector $P(\lambda^*) = \sum_{m=1}^{M} \sum_{k=1}^{K} p_{m,k}^*$ does not satisfy the total power constraint, since the constraint is not enforced explicitly. Hence, our final power allocation values should be multiplied by a constant $\eta = \overline{P} / P(\lambda^*)$ which is then plugged back into the objective in (14) to arrive at our computed primal optimal value

$$\hat{f}^* = \sum_{\mathcal{M}} U_m (\sum_{\mathcal{K}} \log_2 (1 + \eta \rho_{m,k} p_{m,k}^*)) . \quad (39)$$

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue XI, November 2025

In continuous modulation the resource allocation algorithm is as follows.

Step 1: $\forall m,k$, $\lambda^* = \arg\min_{\lambda \geq 0} [\lambda \bar{P} + \sum_{k \in \mathcal{K}} \max_{m \in \mathcal{M}} (U_m(r_{m,k}(\tilde{p}_{m,k}(\lambda)\rho_{m,k}) - \lambda \tilde{p}_{m,k}(\lambda)))]$

Step 2: $\forall m,k$, $p^*_{m,k}(\lambda^*) = \left[\frac{1}{\rho_{0,m}(\lambda^*)} - \frac{1}{\rho_{m,k}} \right]^+$

Step 3: $m^*_k = \arg\max_m \{U'_m(r^*_{m,k}) r_{m,k}(\tilde{p}_{m,k}(\lambda^*)\rho_{m,k}) - \lambda^* \tilde{p}_{m,k}(\lambda^*)\}$

Step 4: $p^*_{m,k} = \tilde{p}_{m,k}(\lambda^*) 1(m = m^*_k)$

The complexity of this algorithm is $O(IMK)$, $O(I)$, $O(I)$, and $O(K)$ in each step, respectively.

If we let f^*(a > 0) and g^*(> 0) be the optimal values of the primal and dual problems given in (14) and (23), and let $\hat{f}^* > 0$ be the computed feasible primal value, the relative duality gap can be bounded as

$$0 \leq \frac{g^* - f^*}{f^*} \leq \frac{g^* - \hat{f}^*}{\hat{f}^*} \qquad (40)$$

The left inequality follows directly from the non-negativity of f^* and the weak duality theorem and the right inequality follow from $\hat{f}^* \leq f^*$.

The following equation is derived by dividing the numerator of (40) by any feasible solution to the primal problem.

$$g^* - \hat{f}^* = \sum_{\mathcal{K}} (U_{m^*_k}(\log_2(1 + \tilde{p}_{m,k}(\lambda^*)\rho_{m^*_k,k}))) + \lambda^*(\bar{P} - \hat{P}(\lambda^*))$$

$$- \sum_{\mathcal{K}} (U_{m^*_k}(\log_2(1 + \tilde{p}_{m,k}(\lambda^*)\rho_{m^*_k,k} \frac{\bar{P}}{\hat{P}(\lambda^*)}))) \qquad (41)$$

$$= \sum_{\mathcal{K}} (U_{m^*_k}(\log_2(\frac{1 + \tilde{p}_{m,k}(\lambda^*)\rho_{m^*_k,k}}{1 + \tilde{p}_{m,k}(\lambda^*)\rho_{m^*_k,k} \frac{\bar{P}}{\hat{P}(\lambda^*)}}))) + \lambda^*(\bar{P} - \hat{P}(\lambda^*)) \qquad (42)$$

One can notice that if $\bar{P} = P(\lambda^*)$, i.e. if our dual optimal powers satisfy the power constraint tightly, the duality gap upper bound is zero, thus the dual optimal and primal optimal solutions are equal and we have solved our problem exactly.

However, the existence of λ^* such that $\bar{P} = P(\lambda^*)$ cannot be guaranteed in general, since $\hat{P}(\lambda^*)$ is a (possibly) discontinuous function of λ, and the discontinuity may actually happen at $\lambda = \lambda^*$ such that the total power does not meet the constraint tightly.

Fortunately, the height of the discontinuity (if it exists) is quite small, and actually diminishes quickly as K increases, and thus the duality gap also diminishes quickly.

This behavior can also be explained analytically by using a generic bound for the duality gap of separable integer programming problems, which when applied to our problem results in

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue XI, November 2025

$$g^* - f^* \le 2 \max_{k\in\mathcal{K}, m\in\mathcal{M}} (U_m(r_{m,k}(\overline{P}\rho_{m,k}))) \quad (43)$$

which can be interpreted as twice the maximum weighted conditional expected rate over all users and subcarriers when all the power is allocated to it.

From (43), we can find that the duality gap bound does not scale with *K*.

If we include the bandwidth term B/K into the per-subcarrier rate, it can be seen that the duality gap diminishes as $K \to \infty$.

Discrete rate optimization

In the discrete rate case, the data rate of the *k*th subcarrier for the *m*th user can be given by the following staircase function.

$$r^d_{m,k}(p_{m,k}\rho_{m,k}) = \begin{cases} r_0, \eta_0 \le p_{m,k}\rho_{m,k} \le \eta_1 \\ r_1, \eta_1 \le p_{m,k}\rho_{m,k} \le \eta_2 \\ \vdots \\ r_{L-1}, \eta_{L-1} \le p_{m,k}\rho_{m,k} \le \eta_L \end{cases} \quad (44)$$

where $\{r_l\}_{l\in L}$, $L = \{1,\dots,L\}$ are the L available discrete information rates in increasing order, and η_l is the SNR boundary chosen in such a way that the information rate r_l is supportable subject to an instantaneous BER constraint.

Then, (14) can be described as follows.

$$\sum_{m=1}^{M}\sum_{k=1}^{K} p_{m,k} \le \overline{P}$$

$$\max U^d = \max_p \frac{1}{M}\sum_{m=1}^{M} U_m(\sum_{k=1}^{K} r^d_{m,k}(p_{m,k}\rho_{m,k})) \quad (45)$$

And the dual problem becomes

$$\theta^d(\lambda) = \lambda\overline{P} + K \max_M \frac{1}{M}(\max_{p_{m,k}}(U_m(r^d_{m,k}(p_{m,k}\rho_{m,k}) - \lambda p_{m,k}))) \cdot \quad (46)$$

For $p_{m,k}$, we have L power allocation functions to choose from.

$$R^l_+ = \left[\frac{\eta_l}{\rho_{m,k}}, \frac{\eta_{l+1}}{\rho_{m,k}}\right), 0 \le l \le L-1$$

$$U'_m(r_{m,k}) r^d_{m,k}(p_{m,k}\rho_{m,k}) - \lambda p_{m,k} = U'_m(r_{m,k}) r_l - \lambda p_{m,k}$$

$$\le U'_m(r_{m,k}) r_l - \lambda \frac{\eta_l}{\rho_{m,k}}, \forall p_{m,k} \in R^l_+ \quad (47)$$

$$\tilde{p}^d_{m,k} \in \left\{\frac{\eta_0}{\rho_{m,k}}, \cdots, \frac{\eta_{L-1}}{\rho_{m,k}}\right\} \quad (48)$$

Here we should find a function that $U'_m(r_{m,k})r_l - \lambda \frac{\eta_l}{\rho_{m,k}}$ is maximized.

$$\tilde{p}^d_{m,k} = \frac{\eta_{l^*_{m,k}}}{\rho_{m,k}} \quad (49)$$

where $\eta_{l^*_{m,k}} \in \arg\max_l \left(U'_m(r_{m,k})r_l - \lambda \frac{\eta_l}{\rho_{m,k}} \right)$. (50)

For $\forall l, 0 \le l \le L-1$

$$U'_m(r_{m,k})r_{l^*_{m,k}} - \frac{\lambda \eta_{l^*_{m,k}}}{\rho_{m,k}} \ge U'_m(r_{m,k})r_l - \frac{\lambda \eta_l}{\rho_{m,k}} \quad (51)$$

$$\frac{r_{\bar{l}} - r_{l^*_{m,k}}}{\eta_{\bar{l}} - \eta_{l^*_{m,k}}} \le \frac{\lambda}{U'_m(r_{m,k})\rho_{m,k}} < \frac{r_{l^*_{m,k}} - r_{\underline{l}}}{\eta_{l^*_{m,k}} - \eta_{\underline{l}}}, \quad \forall \bar{l} > l^*_{m,k}, \forall \underline{l} < l^*_{m,k} \quad (52)$$

$$\max_{l > l^*_{m,k}} \frac{r_l - r_{l^*_{m,k}}}{\eta_l - \eta_{l^*_{m,k}}} \le \frac{\lambda}{U'_m(r_{m,k})\rho_{m,k}} < \min_{l < l^*_{m,k}} \frac{r_{l^*_{m,k}} - r_l}{\eta_{l^*_{m,k}} - \eta_l} \quad (53)$$

$$l^*_{m,k} = \left\{ 0 \le l \le L-1 : \frac{\lambda}{U'_m(r_{m,k})\rho_{m,k}} \in \left[\frac{r_{l+1} - r_l}{\eta_{l+1} - \eta_l}, \frac{r_l - r_{l-1}}{\eta_l - \eta_{l-1}} \right) \right\} \quad (54)$$

After getting λ^* in the same way with the continuous modulation, λ^* determines the optimal subcarrier, rate, and power allocation:

$$m^*_k = \arg\max_m \{ U'_m(r^*_{m,k}) r_{l^*_{m,k}}) - \lambda^* \frac{\eta_{l^*_{m,k}}}{\rho_{m,k}} \} \quad (55)$$

$$R^*_{m,k} = r_{l^*_{m,k}} 1(m = m^*_k) \quad (56)$$

$$p^*_{m,k} = \frac{\eta_{l^*_{m,k}}}{\rho_{m,k}} 1(m = m^*_k) \quad (57)$$

The algorithm for discontinuous modulation is as following.

Step 1: $\forall m,k, \lambda^* = \arg\min_{\lambda \ge 0} [\lambda \bar{P} + \sum_{k \in \mathcal{K}} \max_{m \in \mathcal{M}} (U_m(r^d_{m,k}(\tilde{p}_{m,k}(\lambda)\rho_{m,k}) - \lambda \tilde{p}_{m,k}(\lambda)))]$

Step 2: $\forall m,k, l^*_{m,k} = \left\{ l \in \mathcal{L} : \frac{\lambda}{U'_m(r_{m,k})\rho_{m,k}} \in \left[\frac{r_{l+1} - r_l}{\eta_{l+1} - \eta_l}, \frac{r_l - r_{l-1}}{\eta_l - \eta_{l-1}} \right) \right\}$.

Step 3: $m^*_k = \arg\max_m \{ U'_m(r^*_{m,k}) r_{l^*_{m,k}}) - \lambda^* \frac{\eta_{l^*_{m,k}}}{\rho_{m,k}} \}$

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue XI, November 2025

Step 4: $p^*_{m,k} = \frac{\eta_{l^*_{m,k}}}{\rho_{m,k}} 1(m = m^*_k)$, $R^*_{m,k} = r_{l^*_{m,k}} 1(m = m^*_k)$

The complexity of each algorithm is $O(IMK)$, $O(MK\log(L))$, $O(MK)$ and $O(K)$, respectively.

Simulation Results

Simulation parameters

Table 2 shows the simulation parameters.

Table 2. Simulation parameters

System parameters	Value
Bandwidth (B)	1.25MHz
Number of sub-carriers (K_{fft})	128
Number of used sub-carriers (K)	76
Sampling Frequency (F_s)	1.92MHz
Doppler Frequency (F_d)	200Hz
Cyclic prefix length(L_{cp})	6 samples
Bite Error Rate (BER)	10^{-6}
Maximum Modulation Level (L)	3
Modulation mode	QPSK,16-QAM,64-QAM

Simulation by MATLAB

Channel simulation

The Rayleigh channel is used to simulate the envelope of an individual multipath component.

The parameters of the Rayleigh channel are as follow.

SampTime = 1/1920000;

FreqD = 200;

gainVector = [0 -1.5 -3 -4.5 -6 -7.5 -9];

delayVector = 1.0e-4 * [0 0.01 0.02 0.03 0.04 0.05 0.06];

snr=[0,1,2,3,4,5,6,7,8,9,10];

The Rayleigh channel object is generated by rayleighchan commander in Matlab.

rayChanObj = rayleighchan(SampTime, FreqD, delayVector, gainVector);

modulation

The modulation object is generated by following command.

modObj = modem.qamkmod(2^l);

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue XI, November 2025

modObj.InputType = 'Bit';

where l is modulation level and its default value is 2.

Then number of bit per frame is specified and modulation process is as follow.

msg = randi([0 1],bitsPerFrame,1);

modSignal = modulate(modObj, msg);

The search of λ^*

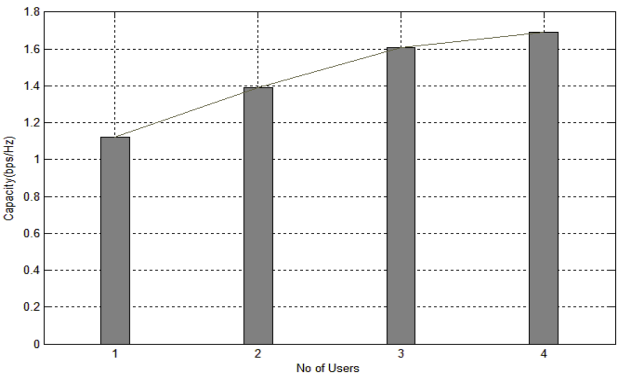
The search of λ^* is as follow.

x = fminbnd(fun,x1,x2);

RESULTS AND DISCUSSION

First let's confirm the multiuser diversity effect in OFDMA system.

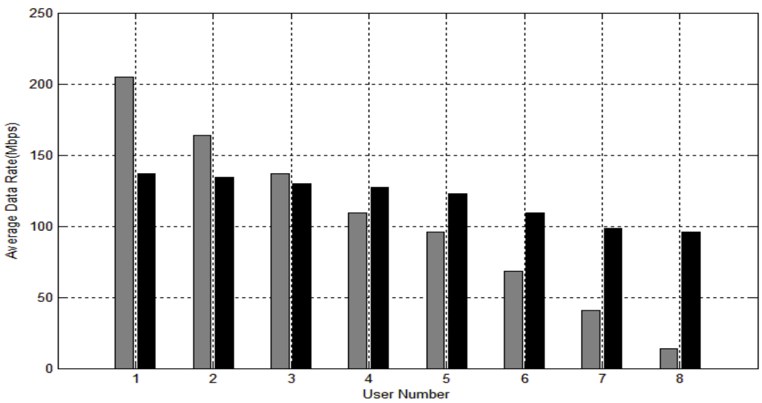
Fig. 2. Multiuser diversity



As can be seen on Figure 2, more increased the number of user, more increased channel capacity in proportion to logarithmic value of users.

Second, the fairness of proposed method was confirmed in Fig. 3.

Fig. 3. Fairness among users

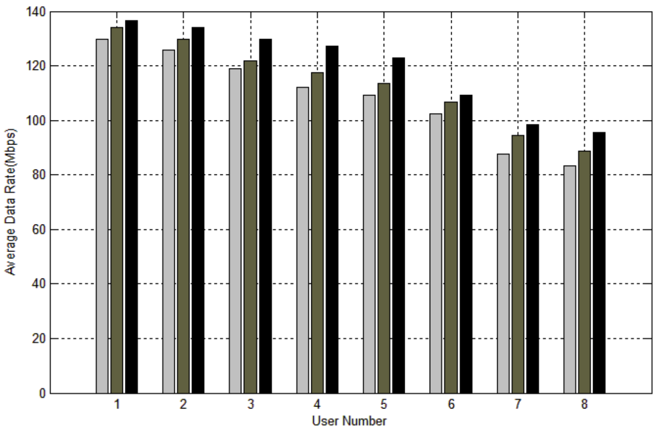


ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue XI, November 2025

As can be seen on Figure 3, the rate sum method cannot provide fairness of resource allocation but utility function provides fairness of resource allocation.

Third, the efficiency of proposed method is shown in Fig. 4.

Fig. 4. Efficiency of proposed system



As can be seen on Figure 4, when the jointed DSA and APA are used simultaneously for optimization by utility function, the efficiency and fairness of resource allocation are provided.

CONCLUSION

We proposed an optimal method for resource allocation in OFDMA (Orthogonal Frequency Division Multiplexing Access) system. We have derived optimal resource allocation algorithms for continuous and discrete rate maximization by modified utility function, and demonstrated the convergence properties of optimization. Simulation results show that the proposed scheme provides the effective tradeoff between fairness and efficiency in radio resource allocation.

Resolved scientific and technical contents in this paper are as follows:

First, we proposed the resource allocation algorithm of OFDMA system based on utility function.

Second, we simulated proposed approach with practical parameters using MATLAB and confirm the advantages of the system proposed in this paper.

We will investigate the optimization under more realistic conditions and develop low complexity approaches for the OFDM wireless network.

ACKNOWLEDGEMENTS

This work was supported by Kim Chaek University of Technology, Democratic People’s Republic of Korea. The supports are gratefully acknowledged. The authors express their gratitude to the editors and the reviewers for their helpful suggestions for improvement of this paper.

CRediT authorship contribution statement

Kon Kim: Investigation, Methodology, Project administration, Software, Writing-original draft.

Funding

This research did not receive the external funding.

Data availability

All data that support the findings of this work are included within this article.

Declarations

Ethics approval

The authors approve to observe the ethics standard of this journal.

Conflict of interest

The authors declare that they have no conflict of interest.

REFERENCES

1. M. Katoozian,(2009). Utility-Based Adaptive Radio Resource Allocation in OFDM Wireless Networks with Traffic Prioritization, IEEE Trans. Wireless Commu., 8(1), 23-29.
2. Ian C. Wong, L. Evans,(2009). Optimal resource allocation in the OFDMA downlink with imperfect channel knowledge, IEEE Trans. on Commu., 57(1), 232-241.
3. Guocong Song, Ye Li,(2005). Cross-Layer Optimization for OFDMA Wireless Networks, IEEE Trans. on Wireless Commu., 4(2), 614-624.
4. F. Khelifa, A. Samet. (2011). A new approach for sub-channels assignment in downlink fourth generation mobile systems, Journal of Computer Science, 7(9): 1368-137.
5. S.Adibi, A.Mobasher, & T.Tofigh (2010). Fourth generation wireless networks. New York: Information science reference(an imprint of IGI global,(chapter 29).
6. Martin D., Werner M., & Afif O., (2009). Radio technologies and concepts for IMT Advanced. John Wiley and Sons, Ltd. (chapter 9).
7. Lei Xu, Ya-ping Li, Qian-mu Li, Yu-wang Yang, Zhen min Tang, Xiao-fei Zang,(2015). Proportional fair resource allocation based on hybrid ant colony optimization for slow adaptive OFDMA system, Information Sciences, 293, 1-10.
8. J.J.Escudero-Garzas, B.bevillers, A.Garcia-Armaola, (2014). Fair-adaptive good put-based resource allocation in OFDMA downlink with ARQ, IEEE Trans. Veh. Technol., 63(3), 1178-1192.
9. J.Joung, S.M.Sum, (2012), power efficient resource allocation for downlink OFDMA relay cellular networks, IEEE Trans. Signal Process, 60(5), 2447-2459.
10. Alireza Sani, Mahmood Mohassel Fegjji, Aliazam Abbasfar, (2014). Discrete bit loading and power allocation for OFDMA downlink with minimum rate guarantee for users, int.J.Electron.Commun.(AEÜ), 68, 602-610.