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An Appropriate Resource Allocation Algorithm for 5G Communication based on OFDMA

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Abstract: In this study, we proposed an appropriate resource allocation algorithm based on Orthogonal Frequency Division Multiple Access (OFDMA) in a downlink system. Recently, a variety of candidate technologies are being discussed to realize 5G network. Among them, massive connectivity with low processing complexity is attracting attention as an important challenge problem. To this end, effective resource allocation schemes with low complexity will become important. Our proposed algorithm which is referred to as an average elimination algorithm can achieve the sub-optimum Bit-Error Rate (BER) and throughput performance with low complexity. In order to demonstrate theefficiency of the proposed algorithm, two types of conventional schemes which are defined as fixed resource allocation and optimal dynamic resource allocation are compared. Through computer simulations we demonstrate the efficiency of the proposed resource allocation algorithm in terms of BER, throughput and processing time.

Key words: Massive connectivity, resource allocation algorithm, downlink OFDMA system, throughput, computational complexity

INTRODUCTION

In 5G communication networks, massive connectivity with low processing complexity is an important challenge problem because the devices using wireless communication networks will be increased exponentially by growing the demands for Internet of Things (IoT) services. However, radio frequency resources for accommodating many devices are limited due to frequency regulations. Therefore, efficient resource utilization technologies are expected to become more important (Oh, 2015; Jeon and Lee, 2015; Ki, 2015; Waterhouse and Novack, 2015; Chang, 2015; Jantasuto, 2015; Skouby and Lynggaard, 2014; Osseiran *et al*., 2014).

The 5G wireless communication should be able to enhance and accommodate various conventional Multiple Access (MA) schemes in addition to new MA schemes (Zhou *et al*., 2014; Sharma *et al*., 2016). Orthogonal Frequency Division Multiplexing (OFDM) has been extensively used in 4G wireless communication industry. In Orthogonal Frequency Division Multiple Access (OFDMA), a subset of the subcarrier is allocated to each user and each subcarrier is assignedexclusively to one user. On this wise, the process of allocating information of various users to a subset of the subcarriers is referred to as resource allocation. The conventional resource allocation schemes can be classified in two types: fixed allocation and dynamic allocation. In the case of fixed allocation, the predetermined time slots and frequency blocks are allocated to users without considering the channel condition (Fong *et al*., 1998). In fixed allocation, the Quality of Service (QoS) on each user's throughput and BERperformance cannot be guaranteed. In the case of the dynamic allocation, the frequency blocks are adaptively allocated to the users according to their channel conditions. That allocation scheme makes full use of multiuser diversity to mitigate degradation of the performance owing to the time-varying characteristics of the wireless channel but there is a drawback that the computational complexity increases significantly (Mao and Wang, 2008).

In this study, we propose a novel resource allocation algorithm which is referred to as an average elimination algorithm. To evaluate the efficiency of the proposed algorithm in terms of the BER, throughput and computational complexity performance, the optimal dynamic resource allocation and fixed resource allocation schemes are compared. The proposed algorithm can provide suboptimum performance of BER and user throughput with low computational complexity in comparison with the optimal dynamic resource allocation. We simulated the proposed algorithm and showed that the desired characteristics were obtained.

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MATERIALS AND METHODS

System model description: Figure 1 shows a downlink OFDMA system model. The proposed channel allocation algorithm is employed in the base station. At the base station, all Channel State Information (CSI) gathered through feedback channels from all users within a service cell is sent to a channel allocation function block. Along with the transmitted OFDM symbols, the resource allocation information should be sent to all users located in the service cell coverage through a separate control channel to demodulate the received signal on theirallocated subcarriers. In our proposed system model, perfect instantaneous channel information assumes that the base station can be available. Also, the number of antennas at the transmitter and receiver is assumed to be one, respectively. Those assumptionsare not practical in realistic wireless environments but it is used to clearly illustrate the effectiveness of the proposed algorithm (Dai *et al*., 2015).

Figure 2 shows the transmission signal spectrum of OFDMA where K is the number of users per cell and the available subcarriers assigned to a user are represented by a frequency block, f for b = 1, 2, …, B. The total number of frequency blocks can be expressed as $f_B = \sum_b f_b$. Also, the bandwidth of f_B is W, the bandwidth ratio

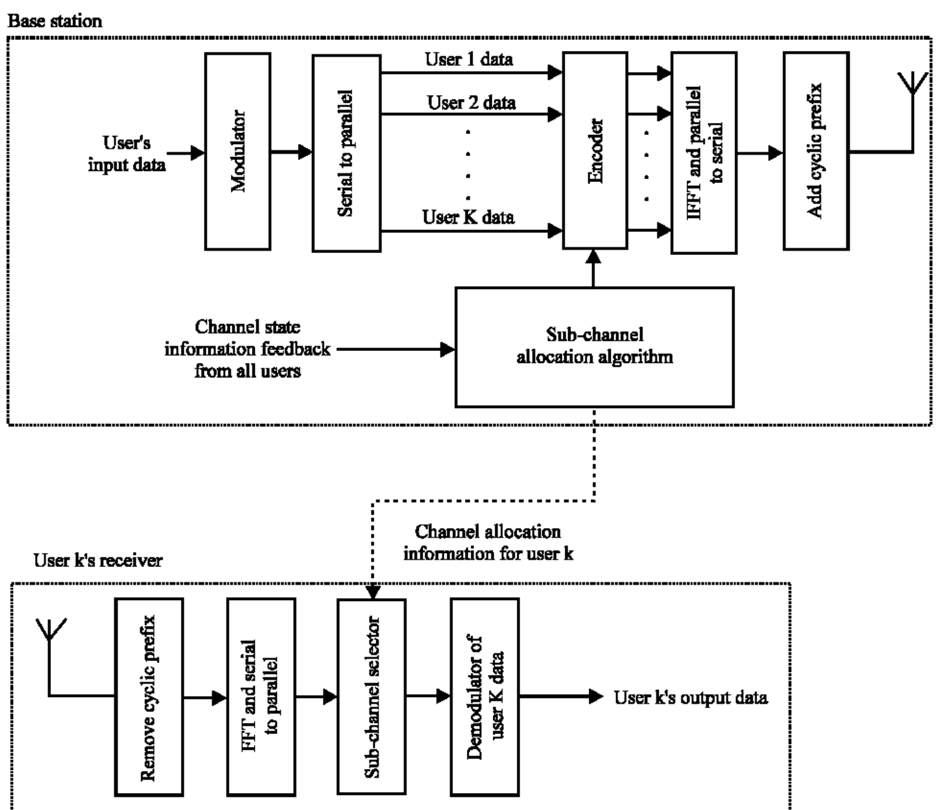

Fig. 1: Block diagram of the proposed system

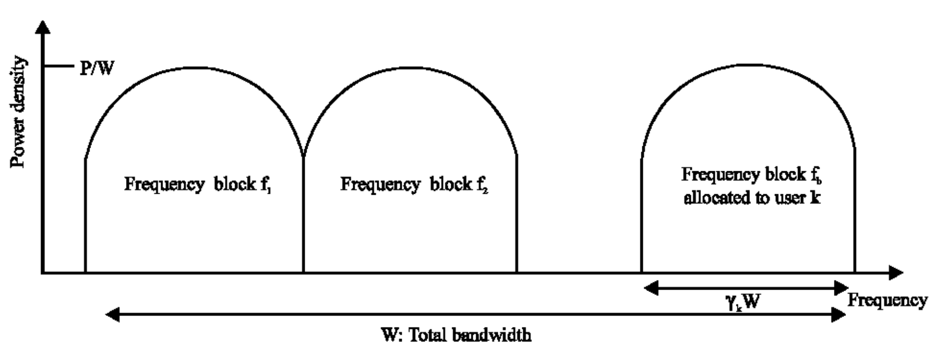

Fig. 2: A simple example of transmission signal spectrum in orthogonal access

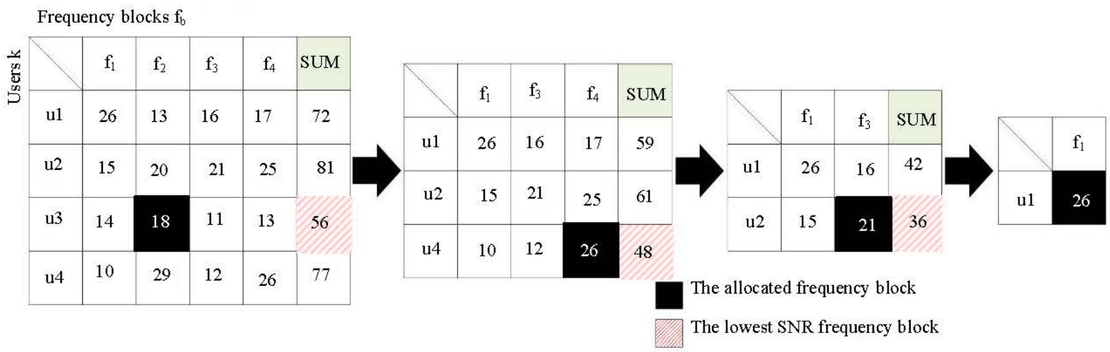

Fig. 3: The procedure of average elimination for 4 users

which is allocated to kth user is referred to as γ_k. At this point, γ_k should be satisfied for $0 \le \gamma_k \le 1$. The power of the transmission signal at the base station denotes P.

Proposed resource allocation algorithm: In th base station, the received CSI are used to calculate the SNR of all users in a cell. To estimate the SNR of each user from CSI, a pilot-based channel estimation was considered (Coleri *et al*., 2002; Lee *et al*., 2015).

Figure 3 demonstrates an example run of the average elimination algorithm for B = 4 frequency blocks and K = 4 users. In Fig. 3, columns represent different users and rows represent different frequency blocks. The detailed procedures of the proposed algorithm are described as follows:

- Step 1: the SNR values of the entire frequency block are obtained from the feedback channel information
- Step 2: calculate the sum of SNR values which are the available frequency blocks per user and then select the user of the lowest total SNR
- Step 3: the highest SNR of the available frequency blocks that the selected user can be only used is allocated
- Step 4: eliminate the user and frequency block that the channel allocation is already completed
- Step 5: repeat the steps from 2-4 until the available frequency blocks are assigned to all users

The proposed algorithm is able to achieve the enhanced user throughput and BER performance in comparison with the fixed resource allocation. Also, it can provide sub-optimum performance ofthose in comparison with the optimal resource allocation. In terms of the computational complexity, the process time of the proposed schemes is increased than the fixed resource allocation and use that less than the optimal resource allocation. In the next study, we will discuss on these properties of the proposed algorithm through the simulation results.

RESULTS AND DISCUSSION

Simulation results: Through computer simulations we evaluate the performance of theaverage elimination resource allocation algorithm. The primary simulation parameters are summarized in Table 1.

In order to evaluate BER and throughput performance, the OFDMA downlink system with 4 users and 4 frequency blocks is assumed. At this system, the SNR values of each user were randomly generated in the range of 0-30 dB. In the case of the computational complexity evaluation, the number of users and frequency blocks is set to 4 and 8, respectively. Further, in order to ensure the reliability of the simulation results, the number of samples was set at 10^6 times.

Figure 4 shows the SNR values allocated to four users according to the resource allocation algorithms. In Fig. 4, the x-axis represents that the SNR values allocated to each user are sorted in order from highest to lowest. The fixed resource allocation achieves the worst channel allocation efficiency. In the case of average elimination resource allocation algorithm, the resource allocation efficiency is better than the fixed allocation but it is degraded compared to the optimal resource allocation. Therefore, the BER and throughput performance of the proposed system are also better than the fixed allocation system and those are slightly degraded in comparison with the optimal allocation system as shown in Fig. 5a and b.

Table 1: Simulation parameters

Parameters	Values
Total bandwidth	40 MHz
Modulation scheme	QPSK
The number of subcarriers and FFT points	256
Symbol rate	156.25 KHz
The number of data symbols	60
The number of pilot symbols	4
The number of samples	10^6
Length of guard interval	25% of a symbol length
Combining scheme	EGC
Fading channel model	18-path exponential Rayleigh

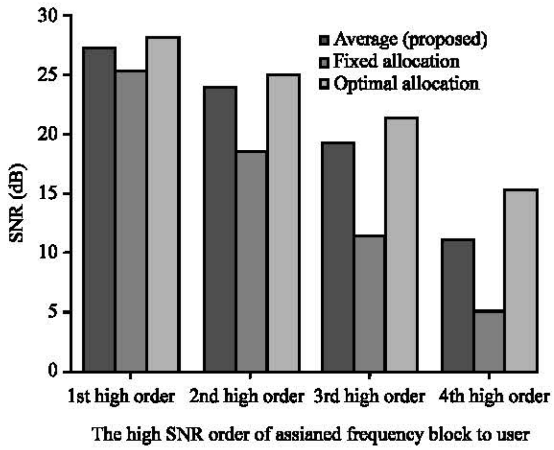

Fig. 4: Comparison of the SNR values allocated to four users according to the resource allocation algorithm types

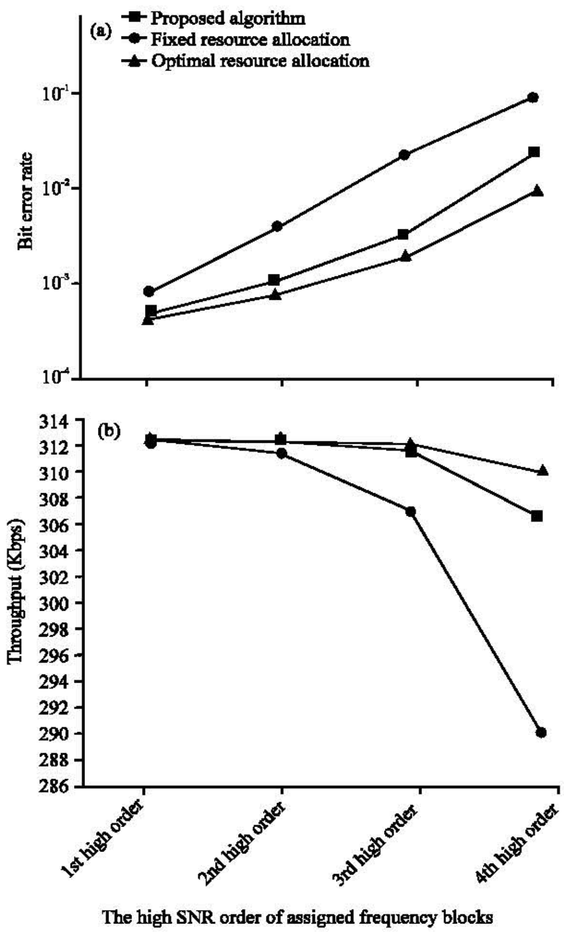

Fig. 5: Comparison of the BER and throughput performance according to the resource allocation types; a) BER results and b) throughput results

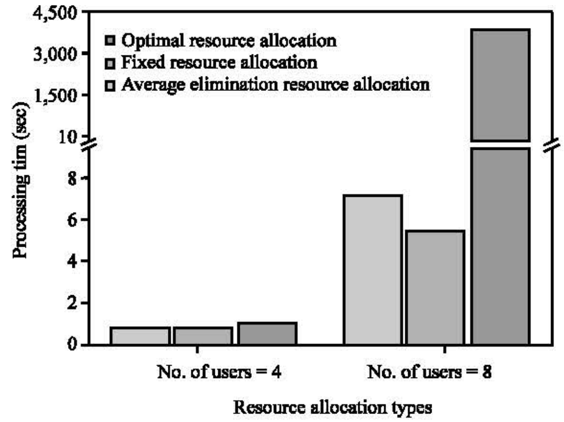

Fig. 6: Comparison of the process time according to the resource allocation types for the number of users at 4 and 8

The computational complexity of eachresource allocation algorithm can be evaluated by using the process time of CPU. Note that to ensure the reliability of the simulation results, the results of Fig. 6 show the processing time taken for the algorithm to 10^6 calculate samples. The process time of the proposed algorithm is slightly higher than the fixed resource allocation but it is less than the optimal resource allocation as shown in Fig. 6. In particular, the process time of the optimal resource allocation is rapidly increased when the number of users is increased. This is because in order to achieve the optimal channel allocation efficiency, the allocation scenario of factorial K (K!) should be considered where K is the number of total users.

CONCLUSION

In this study, a novel average elimination resource allocation algorithm was proposed for downlink OFDMA systems. In order to demonstrate the channel allocation efficiency, the proposed algorithms are compared with the optimal and fixed resource allocation algorithms, respectively. Our proposed schemes were able to achieve the enhanced BER and user throughput performance in comparison with the fixed channel allocation. Also, they can provide suboptimum performance of those in comparison with the optimal resource allocation. In terms of the computatio nal complexity, the process time of the proposed schemes is increased than the fixed resource allocation and use that less than the optimal resource allocation. The reduced complexity of the proposed algorithms will become important in order to realize the massive connectivity for 5G communication system.

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