

# An application of Learning Automata Based ARL to Subchannel Allocation in Cellular OFDMA System

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Orthogonal frequency division multiple access (OFDMA) system have been proposed to provide high data rate transmission in wireless communication [1]. Since the total bandwidth given to an OFDMA system is limited, allocation schemes play a key role in effective use of radio channels. With respect to the fact that multi-cell OFDMA networks are more applicable for practical use, resource allocation in these networks is considered more intensely.

Several algorithms have been proposed to deal with resource allocation problem. These algorithms can be divided into two centralized and distributed categories. The centralized algorithms assign the resources considering the state of all cells [2, 3, 6, 10], while in the distributed ones, the allocation is performed autonomously in each cell without a need to consider the state of the other cells [4, 7]. The heuristic algorithms proposed in [2], [3], [4], [5], and [6] allocate the available resources to minimize total transmission power at the base stations. In [8], a throughput maximization algorithm is proposed in which users experiencing high co-channel interference (CCI) receive fewer resources.

This paper specifically addresses the problem of resource allocation in OFDMA cellular networks using a semi distributed approach. In the proposed method, assignment of subchannels to frequency reuse factor is performed in a centralized manner, while each cell allocates the subchannels to the users independently. We utilize hybrid model based on learning automata and self organizing map to determine FRF of each subchannel. The SOM quantizes the state space of the allocation problem via distributing some neurons in the state space. A learning automaton is associated with each neuron to adaptively select the best FRF for that state.

The algorithm has following steps:

- 1- **MS report:** Each mobile station calculates its SINR and reports it to the associated BS.
- 2- **BS report:** Each BS calculates the achievable data rate and reports it to a RNC that communicates with BSs.
- 3- **FRF assignment:** RNC assigns FRF to each subchannel using associative reinforcement learning.
- 4- **Subchannel allocation to MS:** In a BS, a simple algorithm such as MaxC/I is used to allocates the subchannels to the users.

The number of subchannels for FRF  $f$ ,  $A_f$ , is calculated is calculated with below function:

$$A_7 = \alpha K / 7 \quad (1)$$

$$A_3 = \beta (K - 7A_7) / 3 \quad (2)$$

$$A_1 = K - 3A_3 - 7A_7 \quad (3)$$

Different values for  $\alpha$  and  $\beta$  result in different algorithms. Algorithms with constant values of these parameters do not yield optimal selection of FRF in each state of the cells. It is obvious that for different state of the cells, different values for  $\alpha$  and  $\beta$  should be used. In the proposed method, the values for  $\alpha$  and  $\beta$  are calculated using an associative learning method with feedback signal from environment. It's noteworthy that our algorithm has learning phase which will be used to train the algorithm. When the learning is finished, the learned parameters are used to select the number of FRF. The steps of the algorithm in the learning phase are as follow:



- 1- Calculate  $(N_1^b, N_3^b, N_7^b)$  for all  $b$ . Where  $N_f^b$  is the number of required subchannels of each SRF [10].
- 2- Maximum, minimum, and average of the  $N_f^b$  for all cells is calculated as input to the ARL.
- 3- ARL first determines  $\alpha$  and  $\beta$ , then calculates  $A_f$ .
- 4- After subchannel allocation is done, throughput is calculated and gives to the ARL as reward of the selected action.

When the learning is finished, both of the BS and RNC have computational cost. Each BS allocates the subchannels to the users with a simple algorithm (i.e. MaxC/I) which has very low computational cost. The RNC selects the closest state in the SOM to the current cell state and calculates the  $A_f$  according to learned parameters for that state. As it can be seen when the learning is finished, the task of RNC is trivial and has low computational cost. Also in the learning phase, the proposed model does not have very high computational cost. The used associative RL is comprised of LA and SOM. Both of these models have low computational cost. Figure 2 depicts that the proposed algorithm outperforms the others in almost all situations.

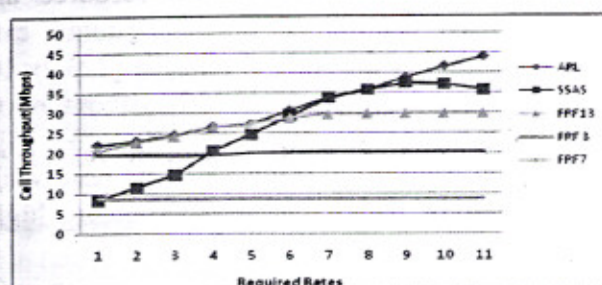


Figure 1 Cell throughput vs. users' required rates

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