Grouping-Based Resource Allocation Scheme for Spectral Efficiency Enhancement of OFDMA WLAN Systems

Moonmoon Mohanty, Jin Ki Kim, Jae-Hyun Kim

Dept. of ECE, Ajou University

OFDMA WLAN 시스템의 스펙트럼 효율 향상을 위한 그룹 기반 자원 할당 방식

모하띠 문문, 김진기 , 김재현
아주대학교 전자공학과

moon28@ajou.ac.kr, kjkcop@ajou.ac.kr, jkim@ajou.ac.kr

Abstract

To utilize the radio resource in orthogonal frequency division multiple access (OFDMA) wireless local area networks (WLANs) efficiently, this paper proposes a resource allocation algorithm based on grouping. The grouping is based on packet size of stations (STAs) and is applicable to systems with stations having variable packet sizes. We evaluate the effectiveness of the algorithm and compare it with existing schemes through simulation.

Ⅰ. Introduction

Due to proliferation of wireless devices and emergence of heterogeneous networks, wireless local area networks (WLANs), which operate in unlicensed band, will be playing a crucial role in next generation wireless communications. In orthogonal frequency division multiple access (OFDMA), multiple stations can transmit data simultaneously on different sub-channels. The most important aspect of OFDMA is that it allows subcarriers to be grouped and assigned to different users. Therefore, it has become an important multiple access technology for WLANs. Its implementation can help to attain the goal of achieving higher throughput, in a dense deployment scenario.

Some recent works on OFDMA WLANs have been presented in [1], [2] and [3]. The authors of [2],[3] have proposed a Medium Access Control (MAC) protocol for WLAN based on OFDMA and CSMA/CA. They have assumed that all stations will be transmitting data of a constant size. The major issue of their design is idle or unused sub-channels (SCHs), or resource wastage. On the other hand, in [1] the authors have proposed a distributed coordination function-based (DCF) MAC protocol, that implements a centralized radio resource management (RRM) for the basic service set (BSS). The channel acquisition is done using conventional DCF. The work in [2] presents a resource allocation algorithm, applied to WLANs containing heterogeneous traffic. However, it suffers from complex scheduling and wasted resource.

The spectral efficiency of OFDMA WLANS is greatly dependent on a promising resource allocation scheme. Hence, in this paper, we focus on reduction of resource wastage, when stations have different packet sizes, by introducing a simplified resource allocation algorithm. The main idea is to form groups of stations according to packet size, followed by resource allocation to each group. Since the grouping is carried out after the stations have been sorted in decreasing order of their packet size, each group contains stations having approximately the same packet size or very less difference. As a result, when stations transmit data in their allocated sub-channels, the channel wastage is less in comparison to the scenario where the AP allocates radio-resource without considering packet size.

Ⅱ. Resource Allocation Scheme

Figure.1 shows the MAC protocol presented in this paper. The BSS consists of 1 access point (AP) and N associated stations. In this scenario, we assume that every station has data to transmit and of different packet size.

The transmission process starts with the exchange of request-to-send/clear-to-send (RTS/CTS) frames. First, the AP broadcasts RTS frame, which contains the STAs' order of reply. All the N stations send their respective CTS in the same order. Following this exchange, the AP executes the resource allocation algorithm and transmits the down-link resource allocation information (DL-RAI) in order to notify assigned sub-channel and transmission time. The next step is data transmission by AP on the allocated sub-channels. Then, the stations inform the AP about their respective packet size as well as acknowledgements, by transmitting downlink acknowledgements (DL-ACK). Using this information, the AP again applies the proposed

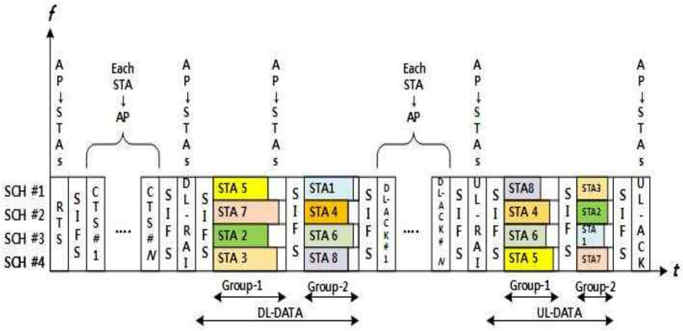

Figure.1 Proposed MAC Protocol procedure

resource allocation algorithm, as seen in Algorithm.1 and indicates the information to all N stations, by announcing uplink resource allocation information (UL-RAI). Then, all STAs send uplink data frames, only on allocated sub-channels. Finally, the AP broadcasts uplink acknowledgement (UL-ACK). The proposed scheme can be applied in uplink as well as downlink transmission. Therefore, we will describe the algorithm for uplink transmission.

The details of the process are depicted in Algorithm.1. After receiving the packet size information from DL-ACKs, the AP sorts all N stations in decreasing order of packet size. This is followed by grouping. Then the AP allocates one sub-channel per station in each group. The transmission time for each group is determined by the maximum packet size in each group. For example, when N=8 and K=4, if stations have following uplink data to transmit with sizes of – 200, 1200, 1000, 600, 1400, 1100, 500 and 300 bytes. Then according to the algorithm in this paper, two groups will be formed with Group2 containing stations which have 600, 500, 300 and 200 bytes and 1400, 1200, 1100 and 1000 will be in Group 1. When this scenario is compared to random allocation, we can see that spectrum utilization is better in our case.

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1: Sort data from stations in decreasing order of packet size with index
   r.
2: for r = 1 : N
3:     add data(r) to group( 1 + mod(r,k))
4: end for
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Algorithm.1 Proposed resource allocation algorithm

Ⅲ. Performance Evaluation

For performance evaluation, we have used throughout as the metric, and compared with Novel-DCF [1]. Table I shows the parameters used in simulation. The parameters used are based on 802.11ac standard. The packets generated by stations are uniformly distributed, and their size is in the range of 200-1500 bytes. Figure.2 shows the throughput versus the number of stations. Here, the throughput is defined as ratio of total data transmitted (uplink and downlink), to the total channel time. From Figure.2 we can see that when the number of stations is lower than the number of sub-channels(K = 4), the performance of both the algorithms is degraded. The reason for degradation is existence of idle sub-channels. However, with increasing number of stations, the performance of both algorithms become better, with the proposed algorithm having higher throughput than [1]. This trend is justified by the fact that, the fragmentation in

TABLE1 : Parameters used for simulation.

Parameter	Value
Bandwidth	20 MHz
Number of sub-channels (K)	4
Number of stations (N)	1 – 16
Physical data rate	65 Mbps
Basic data rate	7.2 Mbps
Length of MAC header	240 bits
Length of PHY header	120 bits
SIFS	10 us

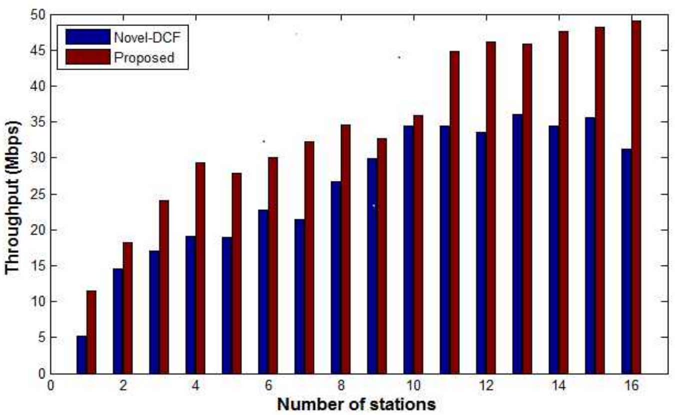

Figure.2 Throughput vs increasing number of stations

[1] gets more complex with increasing number of stations and fewer data is transmitted in some time period. Hence, throughput degrades due to resource wastage. On the contrary, in case of the proposed algorithm, maximum data is transmitted, leading to higher throughput.

Ⅳ. Conclusion

In this paper, we proposed a resource allocation algorithm, which groups the stations on the basis of their packet size, in decreasing order and then assigns sub-channels. From simulation results, we found that the proposed protocol shows enhanced throughput with increasing number of stations.

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