High-Efficient Joint Space Division and Reuse Technology for WLAN

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Abstract

In this paper, an advanced version of joint spatial division and reuse technology is proposed. And a more specific full-duplex multi-user MIMO protocol is proposed to increase spatial using efficiency further.

Ⅰ. Introduction

With the development of technology, there is an explosive increase in communication amount. To provide higher communication amount to multiple users, higher area spectral efficiency is needed.

To satisfy this requirement, a method is to divide and reuse the overall space with using full-duplex communication method.

In previous, the spatial reuse is realized by using different clear channel assessment threshold value in each network based on CSMA/CA theory. Also, there is an initial version of full-duplex protocol in which just focuses on data packet.

In this paper, an advanced joint spatial division and reuse (JSDR) method with a higher spectral efficiency than the previous spatial reuse method and a more detailed full-duplex multiple user protocol is proposed

Ⅱ. Advanced JSDR method

Comparing to previous spatial reuse method, we design a beam management algorithm, which includes sensing beam updating and sending beam selection part to increase the spectral efficiency further.

At first, main AP generates as many sensing beams as the number of antennas dividing the whole area equally to get an initial result about interference signal distribution in coverage area, which is shown in the left side of figure 1. Then, at next round, it would generate more sensing beams along those directions of which interference power is low, as shown in the right side of figure 1. By keeping distributing denser sensing beams in those low interference directions, the entire area with low interference power can be obtained precisely.

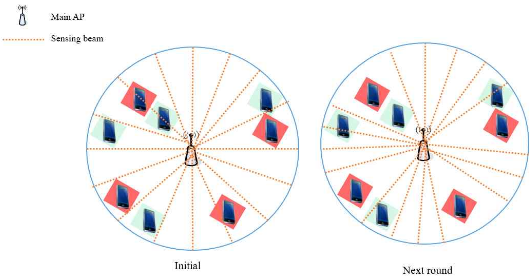

Figure 1. Beam updating model

Since there are as many sensing beams as the number of antenna, assuming main AP has M antennas, there are at most M sensing beam vectors can be generated, which are denoted as $\{\underline{v}_1, \cdots, \underline{v}_M\}$. Assuming the channel in all directions have been known, these channels are denoted as $\{ch_1, \cdots ch_M\}$. After sensing, assume that there are N directions along which interference signal power is lower than threshold value. So, a N column's sending beam candidate matrix $\{\underline{v}_{c_1}, \cdots \underline{v}_{c_N}\}$can be obtained. Since channels information have been known, the relation $\underline{v}_{c_n} = ch_{M(n)}$ can be obtained. Then, we solves the following optimization problem:

$$n = \max_{n} P_{SNR}(\underline{v}_{c_1}, \cdots \underline{v}_{c_N}) \ 0 \le n \le N$$

By checking the SNR value along all directions, we choose the direction which has the maximum SNR to be sending direction and send data packet along that direction.

Ⅲ. FD-MU-MIMO protocol

We also update full-duplex multiple user MIMO protocol, making it more specific

The proposed protocol is shown in figure 2. It has two parts. The first is scheduling part to process overheads. While the second part is data transmission part. Scheduling between AP and STAs will be act at first to provide a treaty for AP and target STAs. And after finish scheduling, data transmission starts.

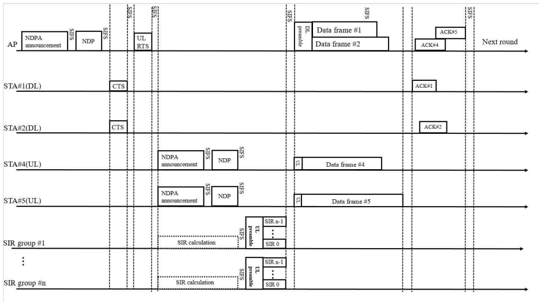

Figure 2 FD-MU-MIMO protocol

Except some packets that are used to schedule between STAs and AP like NDP, NDPA, CTS, RTS packets we also design a signal-to-interference-ratio (SIR) feedback mechanism. As to those STAs which are not going to transmit in current round, they would calculate their nearby interference signal power situation and then send SIR information to AP. After receiving SIR information, AP would use it as a reference to do scheduling in the next round's transmission.

IV. Simulation

In the simulation, we set the area as 100m x 100m. In the area, we design that there are 1 high-efficiency AP with 16 antennas and 10 legacy APs. Each AP has 25 target STAs in average. Transmitting power of both high efficiency AP and legacy AP are 20dBm and the spectrum they used is 20MHz. The carrier-sensing threshold value is -62dBm, which considers the statistics in the high density environment.

Figure 3 is the performance result in the environment set as above. In Case 1, random beam generation and selection is applied in JSDR. While, in Case 2 beam management is applied in JSDR.

We compare JSDR, half and full-duplex in 3 situations. In each situation, sending stage gets start after scheduling stage as designed in proposed protocol.

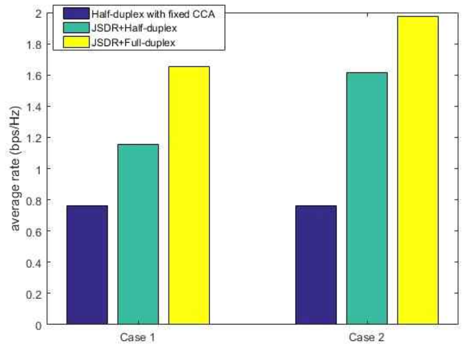

Figure 3. Simulation result

From the result, it can be seen that both JSDR and full-duplex can help to increase spectral efficiency by themselves. Also, there is an increase after applying beam management in JSDR than original random beam generation.

V. Conclusion

In this paper, it shows that applying beam management in JSDR can help to increase spectral efficiency and with the help of a more specific FD-MU MIMO protocol, full-duplex communication can operate properly in a realistic environment.

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