Discuss Report

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I. Introduction

In the paper [1], authors proposed to operate massive Multiple Input Multiple Output (MIMO) cellular Base Stations (BSs) in unlicensed bands (mMIMO-U). They design a procedures required at a cellular BS to guarantee coexistence with nearby WiFi stations in the same piece of unlicensed band via interference alignment technology. Fig. 1 show the flow of mMIMO-U proposed.

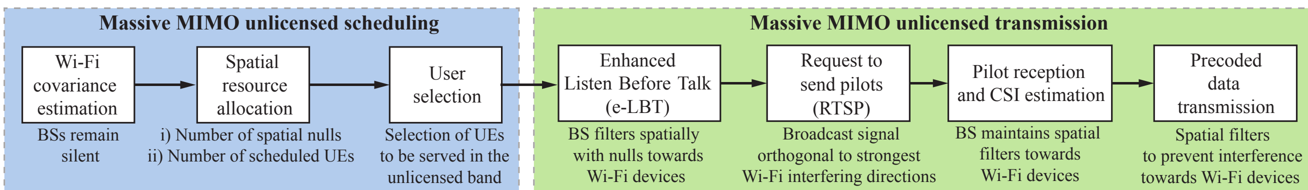

Fig. 1: Flow chart of the proposed mMIMO-U

Step1:
1) acquire channel state information from the neighboring WiFi devices.
2) allocate spatial resources for WiFi interference suppression and user equipment (UE) multiplexing.
3) select a suitable set of UEs to be served in the unlicensed band.

Step2:
1) an enhanced LBT phase.
2) procedures for UE pilot request and channel estimation.
3) precoder calculation.

II. System Model

WE consider the downlink of a cellular network where massive MIMO cellular BSs are deployed to operate in the unlicensed band in a synchronous manner, and communicate with their respective sets of connected cellular UEs, while WiFi devices also operate in the same unlicensed band. Each BSs equipped with a larger number of antennas N, and simultaneously serves K UEs. Each BS transmit with power P_b. On the WiFi side, L is denoted by the set of WiFi devices. We assume that all WiFi device transmit with power P_w. It worth nothing that both UEs and WiFi devices are equipped with one antenna. Without loss of generality, we also assume the same symbol duration for cellular and WiFi transmission. Thus the signal $y_{(i,k)} \in \mathbb{C}$ received by UE k in cell i can be expressed as

$$\begin{aligned} y_{(i,k)}[m] =& \sqrt{P_b} h_{[i,(i,k)]} w_{(i,k)} s_{(i,k)}[m] + \sqrt{P_b} \sum_{k' \in K_i \setminus k} h_{[i,(i,k)]} w_{(i,k')} s_{(i,k')}[m] + \\ & \sqrt{P_b} \sum_{i' \in J \setminus k} h_{[i',(i,k)]} w_{(i',k)} s_{(i',k)}[m] + \sqrt{P_w} \sum_{l \in L} g_{[l,(i,k)]} s_{(l)}[m] + \eta[m] \end{aligned} \tag{1}$$

where $h_{[i,(j,k)]} \in \mathbb{C}^{1\times N}$ is denoted as the channel vector between BS i and UE k in cell$j$. $g_{[l,(j,k)]} \in \mathbb{C}$ is denoted as the channel coefficient between WiFi device l and UE k in cell j. $w_{(i,k)} \in \mathbb{C}^{N\times 1}$ is the precoding vector from BS i to UE k, $s_{(i,k)} \in \mathbb{C}$ and $s_{(l)} \in \mathbb{C}$ is the unit-variance signal transmitted by BS i and WiFi l, respectively. $\eta[m] \sim \mathcal{CN}(0,1)$ is the thermal noise.

A. WiFi Channel Estimation

In this phase, all the BSs remain silent, and thus each BSs i receives the signal from neighboring WiFi devices. We can obtain the interference estimation by

$$
\begin{aligned}
z_i[m] &= \sum_{l \in L} \sqrt{P_w} g_{i,l} s_l + \eta_i[m] \\
Z_i &= \frac{1}{M_c} \sum_{m=1}^{M_c} z_i[m] z_i^{\dagger}[m],
\end{aligned} \tag{2}
$$

which consists of all transmission from active WiFi devices and noise term η is AGWN. The M_c is the length symbol intervals BS keep silent. $g_{i,l} \in \mathbb{C}^{N \times 1}$ is denoted as the channel vector between BS i and WiFi l. $Z_i \in \mathbb{C}^{N \times N}$ is denoted by the estimation covariance of average $Z_i[m]$. Given the estimation Z_i, BS i applies a spectral decomposition, obtaining

$$Z_i = U_i \Lambda_i U_i^{\dagger}, \tag{3}$$

where $\Lambda = diag(\lambda_{i,1},,,\lambda_{i,N})$, such that $\lambda_{i,1} > \lambda_{i,1},,, > \lambda_{i,N})$. In order to allocate Degree of Freedom (DoF), let define the matrix

$$\Sigma_i = [u_{i,1},,,u_{i,D_i}], \tag{4}$$

whose columns contain the D_i dominant eigenvectors of Z_i. For a sufficiently large D_i, $range\{\Sigma_i\}$ represents the channel subspace on which BSs i receives most of the WiFi transmitted power. Therefore, the power transmitted by BS i on $range\{\Sigma_i\}$ represents the major source of the interference for one or more WiFi devices.

III. My Question

It is well known that WiFi applied Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) protocol which channel will be occupied by only one device in one time slot. Therefore it is ineffective that this method estimate channel state information from neighboring WiFi device. It is obvious that this method will estimate major WiFi devices which active with high frequency. Let us consider this case, there is a WiFi device active with low frequency. On the hand, this estimation method will not guarantee this WiFi signal space. On the other hand, the estimation from major WiFi devices will be inaccurate due to this WiFi device.

It is better(maybe) method that we can compute estimation by selecting major WiFi devices.

IV. My plan

Some simulations may be need for verifying my idea.

References

[1] G. Geraci, A. Garcia-Rodriguez, D. López-Pérez, A. Bonfante, L. G. Giordano, and H. Claussen, “Operating massive mimo in unlicensed bands for enhanced coexistence and spatial reuse,” *IEEE Journal on Selected Areas in Communications*, 2017.