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Re:	Response to the Call for Contributions IEEE 802.16m-08/016 — UL MIMO, Interference Mitigation
Abstract	This contribution proposes an enhanced HARQ technique for 802.16m system description document (SDD).
Purpose	To adopt the enhanced HARQ technique proposed herein into IEEE 802.16m system description document (SDD).
Notice	
Release	
Patent Policy	

UL MIMO technique using Interference Cancellation Coding(ICC)

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Abstract

The paper provides a method for UL/DL MIMO along with Interference Cancellation Coding (ICC) between Multi-User streams so that the reliability of UL/DL Multi-User MIMO can be improved. Additionally, the receiver structure is simplified. The simulation results show that significant gain is achieved over the existing Space Time code performance.

Background

The existing 802.16 standard does not describe BS cooperation or MS cooperation with MIMO including Interference Mitigation.

Proposed ICC coding scheme

In the contributions IEEE C802.16m-08/385r1 and IEEE C802.16m-08/697, Ths SICC(Self-Interference Cancellation Coding) is introduced for HARQ scheme on MIMO channel.
The above encoding technique can be applied to MIMO systems in various ways. As described the technique in IEEE C802.16m-08/385r1 and IEEE C802.16m-08/697 is directly applicable to systems where the transmitter has 4 antennas and the receiver has 4 antennas. Additionally, we may consider distributed or cooperative systems where the transmission occurs from distinct transmitters each with 2 antennas. This system is shown in Figure 1. Where two transmitters send two only two rows of the matrix **S.** For example Tx1 can send only the top two rows which depend only of the symbols $\{S_1,S_2\}$, while Tx2 can transmit the bottom two rows which depend only on $\{S_3,S_4\}$. We may also consider the case of two distinct transmitters each with two antennas and this time a receiver with only 2 antennas. In this case we can divide that rows of **S** among the two transmitters in the same way as shown in figure 1, but since the receiver only has two antennas the transmitters must multiplex there transmission in time. That is they cannot transmit simultaneously but rather transmit sequentially. Thus transmitter 1 (Tx1) first transmits

$$\mathbf{S}^{[1]} = \begin{bmatrix} S_1 & -S_2^* & S_1 & -S_2^* \\ S_2 & S_1^* & S_2 & S_1^* \end{bmatrix}$$

And then Tx2 transmits

$$\mathbf{S}^{[2]} = \begin{bmatrix} S_3 & -S_4^* & -S_3 & S_4^* \\ S_4 & S_3^* & -S_4 & -S_3^* \end{bmatrix}$$

The receiver then combines the received signals according to the combining scheme described above. Of course, it is assumed that the channel remains constant over the time interval during which $\mathbf{S}^{[1]}$ and $\mathbf{S}^{[2]}$ are being transmitted.

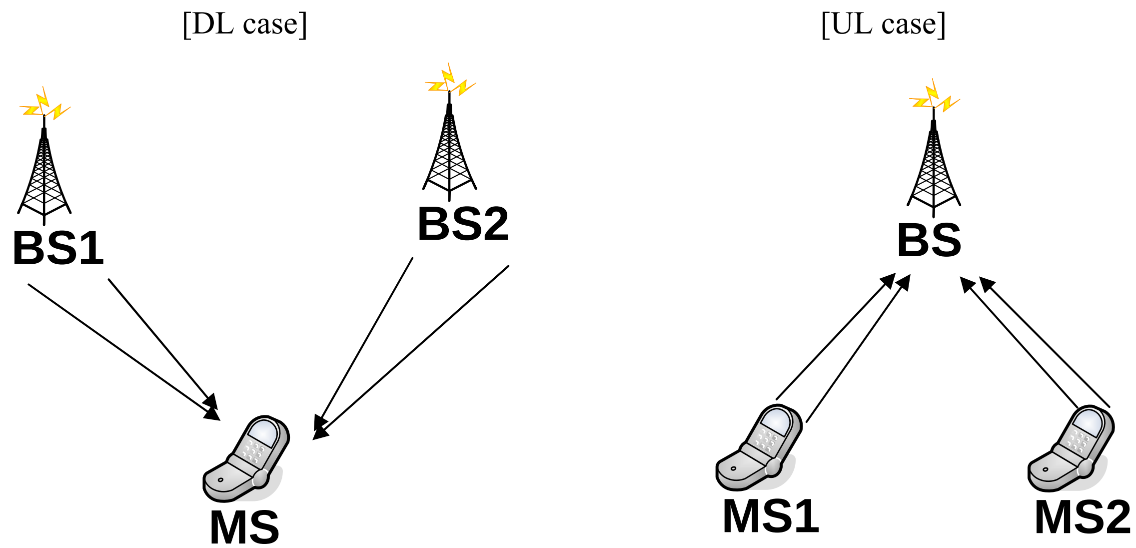

Figure 1.

This scheme can be applied for the following systems;

[DL]

1. BS1(or RS1):2 transmission antennas, BS2(or RS2): 2 transmission antennas,
   MS : 4 received antennas.

2. BS1(or RS1):2 transmission antennas, BS2(or RS2): 2 transmission antennas,
   MS : 2 received antennas(2 time step needed).

[UL]

3. MS1(or RS1):2 transmission antennas, MS2(or RS2): 2 transmission antennas,
   BS : 4 received antennas.

4. BS1(or RS1):2 transmission antennas, BS2(or RS2): 2 transmission antennas,
   MS : 2 received antennas(2 time step needed).

Consequently, the transmission matrix can be described as

$$\mathbf{S} = \begin{bmatrix} S_1 & -S_2^* & S_1 & -S_2^* \\ S_2 & S_1^* & S_2 & S_1^* \\ S_3 & -S_4^* & -S_3 & S_4^* \\ S_4 & S_3^* & -S_4 & -S_3^* \end{bmatrix}.$$

We see that the second column is identical to the existing code in 802.16 and that after its reception a simple linear decoding can be attempted. What is new in this scheme are the 2nd and 3rd columns. This code enables a simple linear receiver that completely cancels self interference and can be seen by the following combing scheme for 4 transmissions.

To obtain S_1 ,

$$\begin{bmatrix} r_{1,1} & r_{1,2}^* & r_{1,3} & r_{1,4}^* \end{bmatrix} \begin{bmatrix} h_{1,1}^* \\ h_{1,2} \\ h_{1,1}^* \\ h_{1,2} \end{bmatrix} + \begin{bmatrix} r_{2,1} & r_{2,2}^* & r_{2,3} & r_{2,4}^* \end{bmatrix} \begin{bmatrix} h_{2,1}^* \\ h_{2,2} \\ h_{2,1}^* \\ h_{2,2} \end{bmatrix}$$

$$+ \begin{bmatrix} r_{3,1} & r_{3,2}^* & r_{3,3} & r_{3,4}^* \end{bmatrix} \begin{bmatrix} h_{3,1}^* \\ h_{3,2} \\ h_{3,1}^* \\ h_{3,2} \end{bmatrix} + \begin{bmatrix} r_{4,1} & r_{4,2}^* & r_{4,3} & r_{4,4}^* \end{bmatrix} \begin{bmatrix} h_{4,1}^* \\ h_{4,2} \\ h_{4,1}^* \\ h_{4,2} \end{bmatrix}$$

$$= 2\left(|h_{1,1}|^2 + |h_{1,2}|^2 + |h_{2,1}|^2 + |h_{2,2}|^2 + |h_{3,1}|^2 + |h_{3,2}|^2 + |h_{4,1}|^2 + |h_{4,2}|^2\right)S_1 + n_1'$$

for S_2 ,

$$\begin{bmatrix} r_{1,1} & r_{1,2}^{*} & r_{1,3} & r_{1,4}^{*} \end{bmatrix} \begin{bmatrix} h_{1,2}^{*} \\ -h_{1,1} \\ h_{1,2}^{*} \\ -h_{1,2} \end{bmatrix} + \begin{bmatrix} r_{2,1} & r_{2,2}^{*} & r_{2,3} & r_{2,4}^{*} \end{bmatrix} \begin{bmatrix} h_{2,2}^{*} \\ -h_{2,1} \\ h_{2,2}^{*} \\ -h_{2,1} \end{bmatrix}$$

$$+ \begin{bmatrix} r_{3,1} & r_{3,2}^{*} & r_{3,3} & r_{3,4}^{*} \end{bmatrix} \begin{bmatrix} h_{3,2}^{*} \\ -h_{3,1} \\ h_{3,2}^{*} \\ -h_{3,1} \end{bmatrix} + \begin{bmatrix} r_{4,1} & r_{4,2}^{*} & r_{4,3} & r_{4,4}^{*} \end{bmatrix} \begin{bmatrix} h_{4,2}^{*} \\ -h_{4,1} \\ h_{4,2}^{*} \\ -h_{4,1} \end{bmatrix}$$

$$= 2\left(\left|h_{1,1}\right|^2 + \left|h_{1,2}\right|^2 + \left|h_{2,1}\right|^2 + \left|h_{2,2}\right|^2 + \left|h_{3,1}\right|^2 + \left|h_{3,2}\right|^2 + \left|h_{4,1}\right|^2 + \left|h_{4,2}\right|^2\right) S_2 + n_1'$$

for S_3,

$$\begin{bmatrix} r_{1,1} & r_{1,2}^{*} & r_{1,3} & r_{1,4}^{*} \end{bmatrix} \begin{bmatrix} h_{1,3}^{*} \\ h_{1,4} \\ -h_{1,3}^{*} \\ -h_{1,4} \end{bmatrix} + \begin{bmatrix} r_{2,1} & r_{2,2}^{*} & r_{2,3} & r_{2,4}^{*} \end{bmatrix} \begin{bmatrix} h_{2,3}^{*} \\ h_{2,4} \\ -h_{2,3}^{*} \\ -h_{2,4} \end{bmatrix}$$

$$+ \begin{bmatrix} r_{3,1} & r_{3,2}^{*} & r_{3,3} & r_{3,4}^{*} \end{bmatrix} \begin{bmatrix} h_{3,3}^{*} \\ h_{3,4} \\ -h_{3,3}^{*} \\ -h_{3,4} \end{bmatrix} + \begin{bmatrix} r_{4,1} & r_{4,2}^{*} & r_{4,3} & r_{4,4}^{*} \end{bmatrix} \begin{bmatrix} h_{4,3}^{*} \\ h_{4,4} \\ -h_{4,3}^{*} \\ -h_{4,4} \end{bmatrix}$$

$$= 2\left(\left|h_{1,3}\right|^2 + \left|h_{1,4}\right|^2 + \left|h_{2,3}\right|^2 + \left|h_{2,4}\right|^2 + \left|h_{3,3}\right|^2 + \left|h_{3,4}\right|^2 + \left|h_{4,3}\right|^2 + \left|h_{4,4}\right|^2\right) S_3 + n_1'$$

and for S_4,

$$\begin{bmatrix} r_{1,1} & r_{1,2}^{*} & r_{1,3} & r_{1,4}^{*} \end{bmatrix} \begin{bmatrix} h_{1,4}^{*} \\ -h_{1,3} \\ -h_{1,4}^{*} \\ h_{1,3} \end{bmatrix} + \begin{bmatrix} r_{2,1} & r_{2,2}^{*} & r_{2,3} & r_{2,4}^{*} \end{bmatrix} \begin{bmatrix} h_{2,4}^{*} \\ -h_{2,3} \\ -h_{2,4}^{*} \\ h_{2,3} \end{bmatrix}$$

$$+ \begin{bmatrix} r_{3,1} & r_{3,2}^{*} & r_{3,3} & r_{3,4}^{*} \end{bmatrix} \begin{bmatrix} h_{3,4}^{*} \\ -h_{3,3} \\ -h_{3,4}^{*} \\ h_{3,3} \end{bmatrix} + \begin{bmatrix} r_{4,1} & r_{4,2}^{*} & r_{4,3} & r_{4,4}^{*} \end{bmatrix} \begin{bmatrix} h_{4,4}^{*} \\ -h_{4,3} \\ -h_{4,4}^{*} \\ h_{4,3} \end{bmatrix}$$

$$= 2\left(\left|h_{1,3}\right|^2 + \left|h_{1,4}\right|^2 + \left|h_{2,3}\right|^2 + \left|h_{2,4}\right|^2 + \left|h_{3,3}\right|^2 + \left|h_{3,4}\right|^2 + \left|h_{4,3}\right|^2 + \left|h_{4,4}\right|^2\right) S_4 + n_1'$$

In the above equations, r_{ij}, is the received symbol at the i^{th} antenna at j^{th} reception time and h_{ij} is the channel coefficient from the j^{th} transmit antenna to the i^{th} receive antenna. We see that the linear combing of the 4 symbols results in the complete cancellation of interference terms.

Performance

We show the performance comparison in IEEE C802.16m-08/697. As we can see in the contribution, the ICC on MIMO have significant gain.

Proposed text for SDD

11.x Physical layer

11.x.y Multi-Use MIMO

References

1. *Standard for Local and metropolitan area networks Part 16: Air Interface for Broadband Wireless Access Systems*, P802.16Rev2/D4 (April 2008)