MIMO-OFDM with ESPAR Antenna

Diego Javier Reinoso Chisaguano, Takeshi Higashino and Minoru Okada
Nara Institute of Science and Technology, Graduate School of Information Science
Network Systems Laboratory

**MIMO-OFDM with ESPAR antenna**

**ESPAR antenna with periodically changing directivity**

- ESPAR (Electronically Steerable Passive Array Radiator).
- It is a small size and low power consumption antenna.
- It is composed by a radiator element connected to the RF front-end and one or more parasitic (passive) elements terminated by variable capacitances.

**System model of MIMO-OFDM with ESPAR antenna**

- Compared to the conventional MIMO-OFDM 2x2 systems, MIMO-OFDM with ESPAR antenna gives additional diversity gain and improves the bit error rate performance without increasing the number of RF front-end circuits.

a) Transmitter

- Based in the WLAN IEEE 802.11n standard

b) Receiver

- For every receiver it uses a 2-elements ESPAR antenna with periodically changing directivity
- It uses the low complexity MMSE sparse-SQRD algorithm for the detection process.

**Compressed Sensing based channel estimation**

- Compressed Sensing (CS) is a set of new algorithms that allows the reconstruction of sparse signals from much fewer measurements.

\[ r = \Psi \Theta + z \]

\[ r = \begin{bmatrix} \Psi \end{bmatrix} \begin{bmatrix} \Theta \end{bmatrix} + z \]

- For MIMO-OFDM with ESPAR antenna, when the pilot symbol is transmitted, the vector of received symbols at the i-th receiver and after the FFT block is given by

\[ u_i = G_{-1} P_i h_{i,1} + G_0 P_i h_{i,0}^0 + G_{-1} P_2 h_{i,2} + G_0 P_2 h_{i,2}^0 + G_{-1} P_3 h_{i,2} + G_0 P_3 h_{i,2}^0 + z \]

- To exploit the sparsity of the channel impulse response, the previous equation can be expressed as

\[ u_i = [G_{-1} P_i, G_0 P_i, G_{-1} P_2, G_0 P_2, G_{-1} P_3, G_0 P_3] \]

- To solve the previous equation, Dantzig Selector (DS) or Orthogonal Matching Pursuit (OMP) algorithms can be used.

**Simulation Results**

**Simulation Settings**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modulation</td>
<td>16-QAM</td>
</tr>
<tr>
<td>Channel bandwidth</td>
<td>20MHz</td>
</tr>
<tr>
<td>Pilot Sequence</td>
<td>HT/TF, P2 Cyclic Shift 850nS</td>
</tr>
<tr>
<td>Number of sub-carriers</td>
<td>56</td>
</tr>
<tr>
<td>FFT size</td>
<td>64</td>
</tr>
<tr>
<td>GI</td>
<td>1/4</td>
</tr>
<tr>
<td>Path model</td>
<td>2 rays Rayleigh frequency selective Fading</td>
</tr>
<tr>
<td>Noise type</td>
<td>AWGN</td>
</tr>
<tr>
<td>Channel Estimation</td>
<td>MMSE, perfect CSI, CS with L = 16</td>
</tr>
<tr>
<td>Detection</td>
<td>MMSE sparse-SQRD</td>
</tr>
</tbody>
</table>

- For a BER of $10^{-3}$ and using perfect CSI, MIMO-OFDM with ESPAR antenna achieves an additional diversity gain of 16dB compared to a common MIMO 2x2 VBLAST system.
- Using CS-based channel estimation with OMP we obtain better estimation accuracy and it improves the BER compared to the MMSE channel estimator.