Preliminary Discussion on Taped-Delay-Line Based MIMO Channel Model

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Purpose:
To discuss the probability assignment for RS above and below rooftop and the standard deviation of lognormal shadowing distribution

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Introduction and Background

• Full Spatial Channel Models (SCM) is available for system level simulation
  – With narrow band limitation (max 5MHz)
  – Very complicated for generation and excessive run time is required
• Simplified Taped-Delay-Line MIMO channel model can be employed
  – For both link level and system simulations
• We discuss the MIMO channel generation method
  – Independent MIMO channel generation
  – Correlated MIMO channel generation
Methodology

• A tapped-delay-line based MIMO model is used for link level performance evaluation
  – It is a simplified MIMO propagation channel model

• The link level propagation aspects are captured by impulse response model
  – E.g. ITU channel model for narrow band (5MHz) channel

• The independent multiple Rayleigh faders are employed
  – Li-Hung model

• The MIMO-antenna /MIMO-channel correlation aspects are captured by correlation factor
Channel Model-Time Structure

- Tapped delay line model

\[
H_1(t) = \begin{bmatrix}
    h_{1,1}(t) & h_{1,2}(t) \\
    h_{2,1}(t) & h_{2,2}(t) \\
    h_{3,1}(t) & h_{3,2}(t) \\
    h_{4,1}(t) & h_{4,2}(t)
\end{bmatrix} \quad
H_2(t) = \begin{bmatrix}
    h_{1,1}(t) & h_{1,2}(t) \\
    h_{2,1}(t) & h_{2,2}(t) \\
    h_{3,1}(t) & h_{3,2}(t) \\
    h_{4,1}(t) & h_{4,2}(t)
\end{bmatrix} \quad
H_n(t) = \begin{bmatrix}
    h_{1,1}(t) & h_{1,2}(t) \\
    h_{2,1}(t) & h_{2,2}(t) \\
    h_{3,1}(t) & h_{3,2}(t) \\
    h_{4,1}(t) & h_{4,2}(t)
\end{bmatrix}
\]
ITU Channel Model Parameters (Examples)

- 3 ITU channel models

<table>
<thead>
<tr>
<th>Tap</th>
<th>OIP-A</th>
<th>OIP-B</th>
<th>V-A</th>
<th>Doppler spectrum</th>
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<tbody>
<tr>
<td></td>
<td>Relative Delay (ns)</td>
<td>Average Power (dB)</td>
<td>Relative Delay (ns)</td>
<td>Average Power (dB)</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>110</td>
<td>-9.7</td>
<td>200</td>
<td>-0.9</td>
</tr>
<tr>
<td>3</td>
<td>190</td>
<td>-19.2</td>
<td>800</td>
<td>-4.9</td>
</tr>
<tr>
<td>4</td>
<td>410</td>
<td>-22.8</td>
<td>1200</td>
<td>-8.0</td>
</tr>
<tr>
<td>5</td>
<td>-</td>
<td>-</td>
<td>2300</td>
<td>-7.8</td>
</tr>
<tr>
<td>6</td>
<td>-</td>
<td>-</td>
<td>3700</td>
<td>-23.9</td>
</tr>
</tbody>
</table>

- Need to improve ITU model to wider bandwidth channel (more than 6 taps)
Correlated MIMO Channel Model – (1)

\[ R_R = LL^H \] (L is lower triangular Cholesky RX correlation)

\[ R_T = UU^H \] (U is upper triangular Cholesky TX correlation)

* We assume the receive antennas are uncorrelated
Correlated MIMO Channel Model –(2)

\[ R = \begin{pmatrix}
1 & \rho & \rho^2 & \rho^3 \\
\rho & 1 & \rho & \rho^2 \\
\rho^2 & \rho & 1 & \rho \\
\rho^3 & \rho^2 & \rho & 1
\end{pmatrix} \]

<table>
<thead>
<tr>
<th>( \rho )</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>6</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>High</td>
<td>0.7</td>
<td>0.7</td>
<td>0.7</td>
<td>0.85</td>
<td>0.85</td>
</tr>
</tbody>
</table>
Generation of Correlated MIMO Channel Model

- **STEP-1:** Specify the number of transmit antennas $N_T$ and the number of receive antennas $N_R$.
- **STEP-2:** Select a tapped delay line model for the channel dispersion, where this is applied to all of the $N_T \times N_R$ MIMO path.
- **STEP-3:** Apply an independent complex Gaussian sample to each tap on each MIMO path to form $H$. The $H$ is constructed in such a way that the correlation between any pair of fading taps will be zero. Consequently, the correlation matrix for every tap position will simply be an identity matrix.
- **STEP-4:** Specify a correlation matrix for each tap position.
- **STEP-5:** Perform a Cholesky factorization of the correlation matrix $R$, such that $R = UU^H$.
- **STEP-6:** The uncorrelated taps at a given delay position can then be correlated by multiplying the uncorrelated $H$ by the transform matrix $H_C = HU$. 
Summary and Discussion

• Simplified MIMO channel model is discussed
  – Based on Taped-delay-line model
• Channel model extension to for wideband is required
• Channel model and associated correlation factors are required for the MMR links
  – BS-RS, RS-RS, BS-MS, RS-MS