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Title	**MIMO Channel Modeling for 802.16m**
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Re:	Call for Contributions on Evaluation Methodology and Key Criteria for 802.16m – Advanced Air Interface - Proposals, 01/18/07
Abstract	This document present the MIMO channel modeling method for 802.16m,and describe how the modeling method apply to 802.16m link level simulation .Some different modeling Parameters is introduced for different MIMO scenarios.
Purpose	Propose MIMO channel modeling method for 802.16m
Notice	
Release	
Patent Policy and Procedures	

MIMO Channel Modeling for 802.16m

Instructions

MIMO plays an important role in PHY layer of IEEE 802.16e standard. Because 802.16e standard does not provide valid MIMO evaluation methodology for link level simulation, we have no uniform criterion to evaluate link level result of different companies. This document presents the MIMO channel modeling method for IEEE 802.16m, and describes how the modeling method apply to IEEE 802.16m link level simulation. Some different modeling parameters are introduced for different MIMO scenarios.

1 MIMO Channel model

For typical MIMO channel, there are many scatter objects near transmitter and receiver. Scatter objects will create many subpaths which have same time delay and different arrival angle. $\Phi_{p,l}^{Tx}$ is the *l*th subpath DOA(angle of departure) of the *p*th path. $\Phi_{p,l}^{Rx}$ is *l*th subpath AOA(angle of arrival) of the *p*th path. $\sigma_p(\Phi_p^{Rx})$ is azimuth spread of *p*th path. The relation of them is denoted by the equation below.

$$\sigma_p(\Phi_p^{Rx}) = \sqrt{\frac{1}{L}\sum_{l=0}^{L-1}(\Phi_{p,l}^{Rx})^2 - \left(\frac{1}{L}\sum_{l=0}^{L-1}\Phi_{p,l}^{Rx}\right)^2}\ .$$

Provided that antenna of the receiver is far from the transmitter and the signal received is plane wave. Signal delay of *r*th antenna is $\Delta_{p,r}^{Rx}$ comparing with signal of first antenna.

$$\Delta_{p,r}^{Rx} = \frac{(r-1)d^{RX}\sin\Phi_p^{Rx}}{c}$$

d^{Rx} is the distance between two adjacent Rx antenna. Signal phase deflection of *r*th Rx antenna is $\phi_{r,p}^{Rx}$ comparing with signal of first Rx antenna.

$$\phi_{r,p}^{Rx} = 2\pi\Delta_{p,r}^{Rx}\frac{c}{\lambda}$$

Channel vector of all receive antennas is

$$\alpha_p^{Rx} = \left[1 \quad e^{j\phi_{1,p}^{Rx}} \quad \dots \quad e^{j\phi_{M^{Rx}-1,p}^{Rx}}\right]$$

Transmitter is the same, signal delay of *m*th antenna is $\Delta_{p,m}^{Tx}$ comparing with signal of first Tx antenna.

$$\Delta_{p,m}^{Tx} = \frac{(m-1)d^{Tx}\sin\Phi_p^{Tx}}{c}$$

d^{Tx} is the spacing between two adjacent Tx antennas. Signal phase deflection of *m*th Tx antenna is $\phi_{m,p}^{Tx}$

comparing with signal of first Tx antenna.

$$\Phi_{m,p}^{Tx} = 2\pi \Delta_{p,m}^{Tx} \frac{c}{\lambda}$$

Channel vector of all receive antennas is

$$\alpha_p^{Tx} \quad 1 \quad e^{j\Phi_{1,p}^{Tx}} \quad \ldots \quad e^{j\Phi_{M^{Tx}-1,p}^{Tx}}$$

We can not recognize all reflected wave for receiver in time domain. With MS or scatter objects's moving, length of every path will change, and this will result in time selective fading. For moving velocity v, the most frequency deflection is $f_d \quad v/\lambda$, f_c is carrier frequency. The fading coefficient between mth Tx antenna and rth Rx antenna is

$$\beta_{p,m,r}(t) \quad \frac{1}{\sqrt{L}} \sum_{l=0}^{L-1} a_m(\Phi_{p,l}^{Tx}) a_r(\Phi_{p,l}^{Rx}) v_{p,l} e^{j2\pi f_d \cos(\Phi_{p,l}^{Tx})}$$

In proposed MIMO channel model, $\Phi_{p,l}^{Rx}$ (AOA) and $\Phi_{p,l}^{Tx}$ (DOA) of every subpath are two key parameters. Usually we get the Φ_p^{Rx} and Φ_p^{Tx} of the path and azimuth spread distribution by which we can calculate the $\Phi_{p,l}^{Rx}$ and $\Phi_{p,l}^{Tx}$ easily. The another key parameter in model is v, by which we can calculate the Doppler frequency deflection. $v_{p,l}$ is fading coefficient of every subpath.

2.MIMO Channel modeling method

As we know, spatial correlation can describe the spatial fading of multiply antenna system. Spatial correlation will have relation with many factors, such as AOA, DOA, azimuth spread, spacing of antenna, and so on. Firstly, we think about the spatial correlation of channel near receiver. The spatial fading correlation matrix of pth path is R_p^{Rx}

$$R_p^{Rx} \quad \sum_{l}^{L-1} a(\Phi_{p,l}^{Rx}) \; a^H(\Phi_{p,l}^{Rx})$$

In the above equation, $\Phi_{p,l}^{Rx}$ is an angle between $\Phi_{p,l}^{Rx} \quad \sigma_p(\Phi_p^{Rx})$ and $\Phi_{p,l}^{Rx} \quad \sigma_p(\Phi_p^{Rx})$, $\sigma_p(\Phi_p^{Rx})$ is azimuth spread of pth path.

The less azimuth spread is, the bigger correlation of spatial fading is. Whereas the bigger azimuth spread is the less correlation of spatial fading is.

Same as channel near receiver, spatial correlation matrix of channel near transmitter is R_p^{Tx}

$$R_p^{Tx} \quad \sum_{l}^{L-1} a(\Phi_{p,l}^{Tx}) \; a^H(\Phi_{p,l}^{Tx})$$

From the R_p^{Rx} and R_p^{Tx}, we can acquire the whole spatial correlation matrix

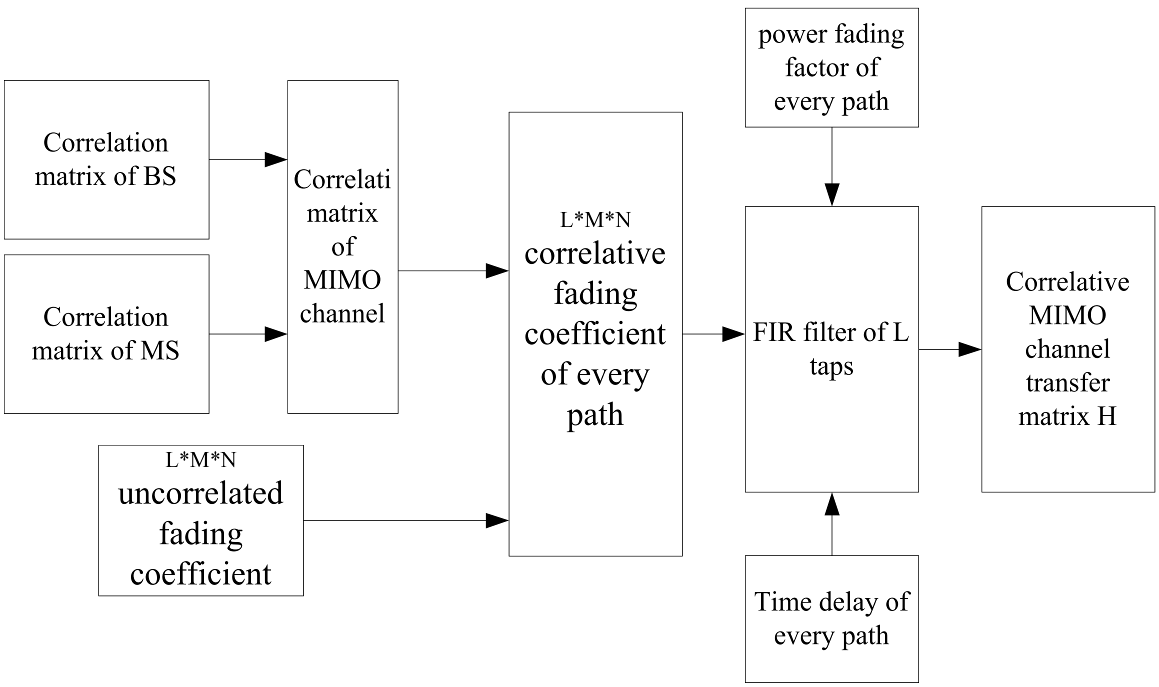
$$\Gamma \quad R_p^{Tx} \quad R_p^{Rx} \quad C_p C_p^T$$

“ ” represent Kronecker product , C_p is Cholesky decomposition result of matrix Γ.

$$H_p \quad \sqrt{P_p} C_p a_p$$

$H_p \quad h_{11}^{(p)} h_{21}^{(p)} .. h_{N1}^{(p)} h_{12}^{(p)} h_{22}^{(p)} .. h_{NM}^{(p)}$ is the channel transfer matrix of channel.

P_p is the power of pth path. Every $a_i^{(p)}$ is irrelevance fading coefficient of $a_p = a_1^{(p)} a_2^{(p)} .. a_{NM}^{(p)}$ .Accordingly, you can realize the simulation for spatial correlation MIMO channel by the above equation. As shown in the follow figure, several steps need to be taken in this channel modeling.



(1) First, uncorrelated fading coefficient of vector a_p can be acquired by simulating a single antenna channel Model.

(2) According to the spatial parameter, we can calculate the correlation matrix of MS and BS. Next, correlation matrix of channel can be acquired.

(3) After uncorrelated fading coefficients of vector a_p have been multiplied by the correlation matrix of MIMO channel, the result represents not only the channel fading information but also the channel correlation information.

(4) Every coefficient of correlative fading will be filtered by a filter with L taps, in which course, time delay

and power of path will be considered.

(5) The output of filter is Correlative MIMO channel transfer matrix H.

3. MIMO channel parameter for different scenario

Because scenario is the key factor of MIMO channel modeling, some typical scenarios will be proposed. Corresponding to these scenarios, we should consider several MIMO channel parameter as follows.

	Suburb (macro)	Hill(macro)	Urban(macro)	Marketplace(micro)	Indoor(mini micro)
Delays spread(us)	0.5	5	20	0.3	0.1
Azimuth spread(^{0})	1	20	30	120	360
Doppler spread(Hz)	190	120	190	10	5
Path num	2	6	6	6	6
Subpath num	10	20	20	20	20
PAS(power azimuth spectrum)	Laplacian distribution	Laplacian distribution	Laplacian distribution	Laplacian distribution	Uniform distribution