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Title	**MIMO Channel Model for MBWA**
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Re:	
Abstract	This contribution presents the METRA MIMO channel model as the MIMO channel model for MBWA system. MIMO channel parameters are also given as an example.
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MIMO Channel Model for MBWA

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March 2003

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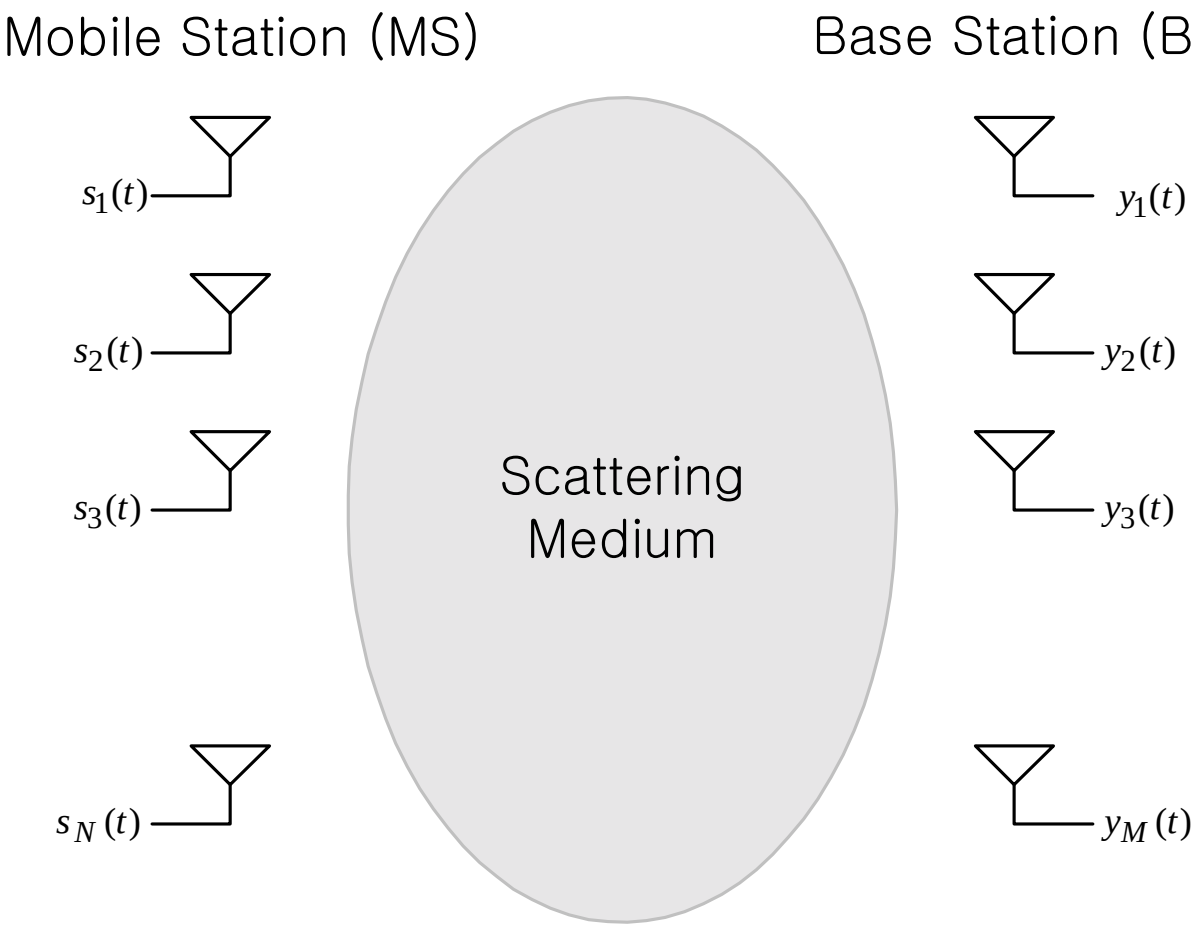
Introduction

- Use of multiple transmit and multiple receive antenna, known as MIMO (Multiple Input Multiple Output) system, is gaining interest for next generation mobile wireless communication systems.
- It has been shown by Foschini [1], MIMO system can achieve enormous capacity gain from multiple parallel sub-channels created in rich scattering environment.
- Recently, spectral efficiencies ranging 20-40bit/s/Hz with 30kHz bandwidth were demonstrated at Lucent using V-BLAST (Vertical – Bell Laboratories Layered Space Time) system in MIMO environment.

MIMO Channel



MIMO Channel

- **METRA Model**
  - Combines independent complex Gaussian correlation matrices at the transmitter and receiver for MIMO correlation matrix.
  - ITU model is used for modeling power delay profile.
  - Realistic and easy-to-use with backward compatibility to ITU model.
  - AWGN, shadowing, and path loss models are not included.
- **Ray-Tracing Model**
  - Models location of scatterers by following the propagation path through the channel.
  - Provides fairly accurate channel prediction.
  - Too complex for major outdoor environment.
- **Scattering Model**
  - Assumes particular distribution of scatterers.
  - Generates channel modeling through interaction of scatterers and planar wavefronts.
  - Requires large number of parameters.

METRA Channel Model

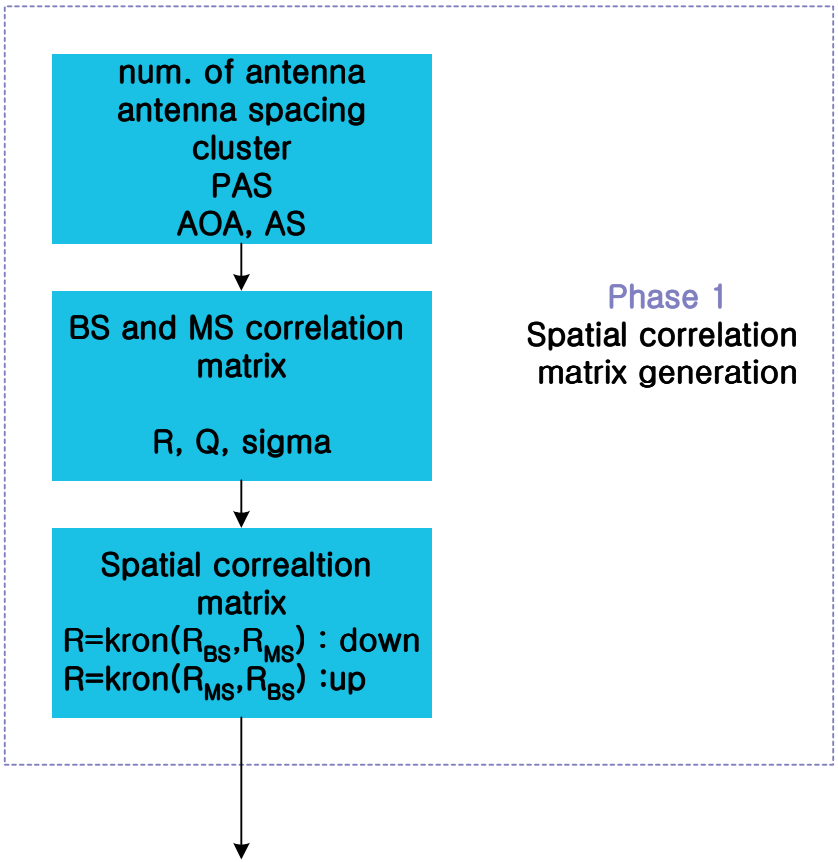
- The METRA Project is one of the various projects under the IST (Information Society Technologies) Program.
- The METRA Consortium
  - Universitat Politecnica de Catalunya
  - Aalborg University
  - Nokia Networks
  - Nokia Mobile Phones
  - Vodafone Ltd
- The METRA Project builds on the previous EC funded projects on smart antennas for mobile communications
  - TSUNAMI (Technology in Smart Antennas for Universal Advanced Mobile Infrastructure Project)
  - SUNBEAM (Smart Universal Beamforming)

METRA Channel Model

- According to [2-3], the METRA MIMO channel model uses generalized tap delay line model with time variation specified by Doppler spectrum.
- The correlation matrices to characterize the MIMO channel are defined by
  - Power azimuth spectrum (PAS)
  - Azimuth spread (AS)
  - Mean angle of arrival (AoA)
  - Antenna spacing.
- The METRA MIMO model's power delay profile is based on the ITU channel profile, therefore backward compatible with widely used ITU SISO model.

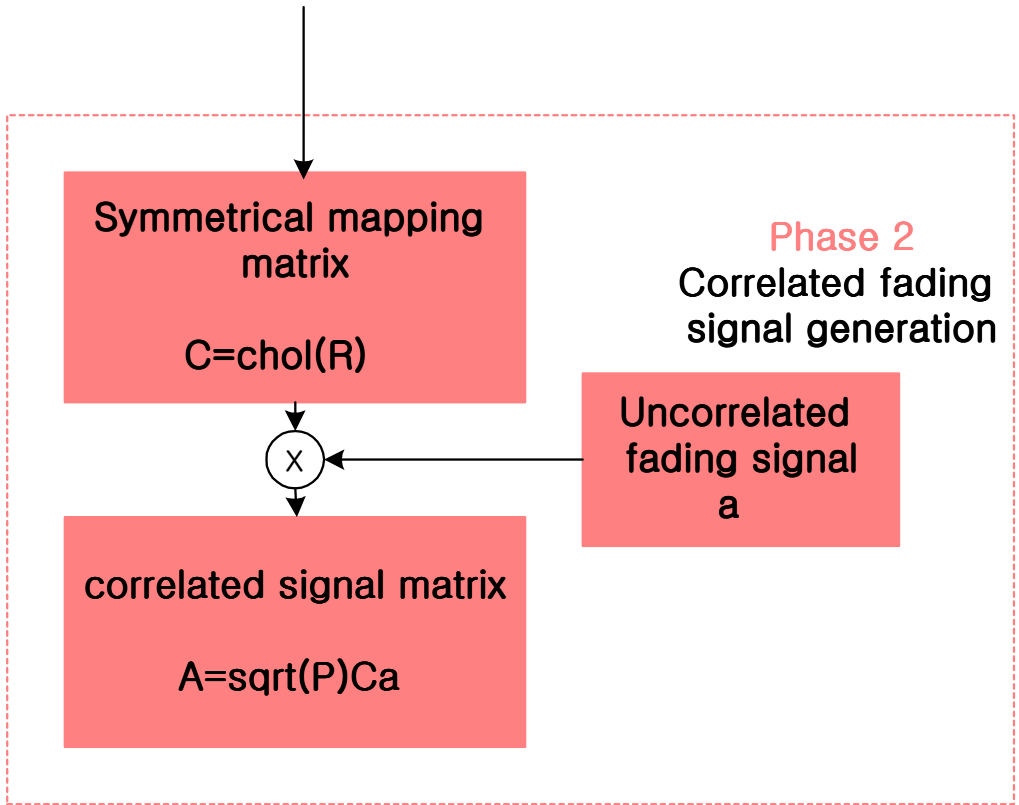
METRA Channel Model

Channel Modeling Procedures



METRA Channel Model

Channel Modeling Procedures (Cont.)



METRA Channel Model

- MIMO Channel Parameters (source: 3GPP TR 25.876 V1.0.1)

		Case A Rayleigh Uncorrelaed	Case B Macrocell Ped A	Case C Macrocell Veh A	Case D Microcell/Bad-urban PedB
Number of paths		1	4	6	6
PDP		N/A	ITU Pedestrian A	ITU Vehicular A	ITU Pedestrian B
Doppler spectrum		Classical	Classical	Laplacian	Laplacian
Speed(km/h)		3/40/120	3/40/120	3/40/120	3/40/120
UE	Topology	N/A	0.5λ spacing	0.5λ spacing	0.5λ spacing
	PAS	N/A	Path #1, Rician, K=6dB Uniform over 360	Laplacian, AS=35 (Uniform over 360)	Laplacian, AS=35 (Uniform over 360)
	DoM(deg)	N/A	0	22.5	-22.5
	AoA(deg)	N/A	22.5	67.5 (all path)	22.5 (odd paths) -67.5 (even paths)
Node B	Topology	N/A	Uniform linear array: 1) 0.5λ spacing 2) 4.0λ spacing		
	PAS	N/A	Laplacian, AS=5	Laplacian, AS=10	Laplacian, AS=15
	AoA	N/A	20,50[1)]	20,50[1)]	2,-20,10,-8,-33,31[2)]

METRA Channel Model

Correlation Matrix for 4TX-4RX:

Case B

$$\begin{bmatrix} 1 & 0.4640+0.8499i & -0.4802+0.7421i & -0.7688-0.0625i \\ 0.4640-0.8499i & 1 & 0.4640+0.8499i & -0.4802+0.7421i \\ -0.4802-0.7521i & 0.4640-0.8499i & 1 & 0.4640+0.8499i \\ -0.7688+0.0625i & -0.4802-0.7421i & 0.4640-0.8499i & 1 \end{bmatrix}$$

Node B

Laplacian, AS=5°,
0.5 λ, AOA=20°

$$\begin{bmatrix} 1 & -0.3043 & 0.2203 & -0.1812 \\ -0.3043 & 1 & -0.3043 & 0.2203 \\ 0.2203 & -0.3043 & 1 & -0.3043 \\ -0.1812 & 0.2203 & -0.3042 & 1 \end{bmatrix}$$

UE

Uniform, K=6dB
0.5λ , AOA=22.5°

Case C

$$\begin{bmatrix} 1 & 0.4290+0.7766i & -0.3642+0.5475i & -0.4527-0.0502i \\ 0.4290-0.7766i & 1 & 0.4290+0.7766i & -0.3642+0.5475i \\ -0.3642-0.5475i & 0.4290-0.7766i & 1 & 0.4290+0.7766i \\ -0.4527+0.0521i & -0.3642-0.5475i & 0.4290-0.7766i & 1 \end{bmatrix}$$

Node B

Laplacian, AS=10°,
0.5λ , AOA=20°

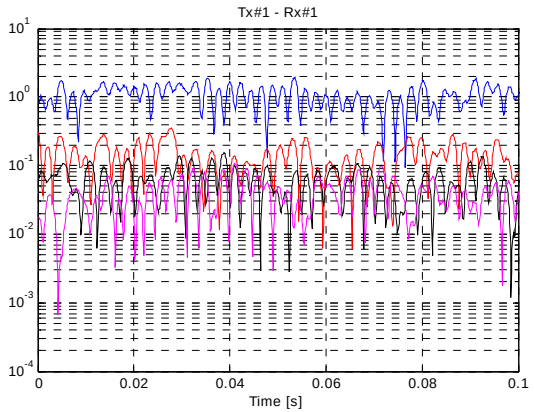
$$\begin{bmatrix} 1 & -0.6906+0.3419i & 0.4903-0.3626i & -0.3733+0.3450i \\ -0.6906-0.3419i & 1 & -0.6906+0.3419i & 0.4903-0.3626i \\ 0.4903+0.3626i & -0.6906-0.3419i & 1 & -0.6906+0.3419i \\ -0.3733-0.3450i & 0.4903+0.3626i & -0.6906-0.3419i & 1 \end{bmatrix}$$

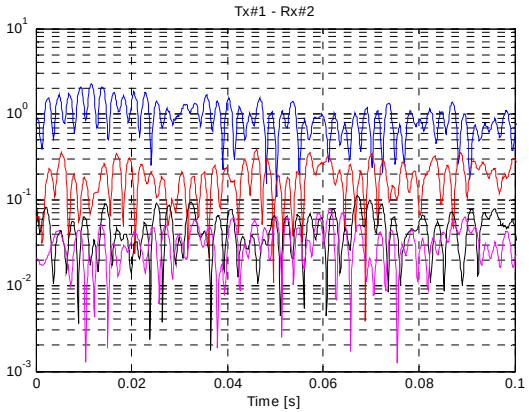
UE

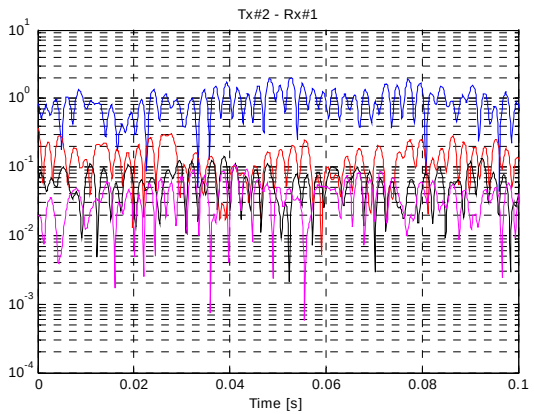
Laplacian, AS=35°, DOM=22.5°
0.5λ , AOA=67.5°

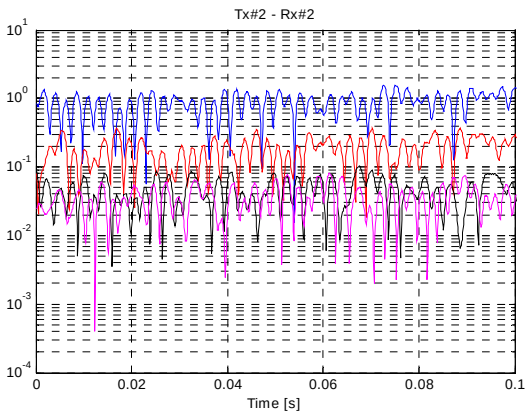
METRA Channel Model

METRA Model Case B (2TX-2RX) Channel Gain



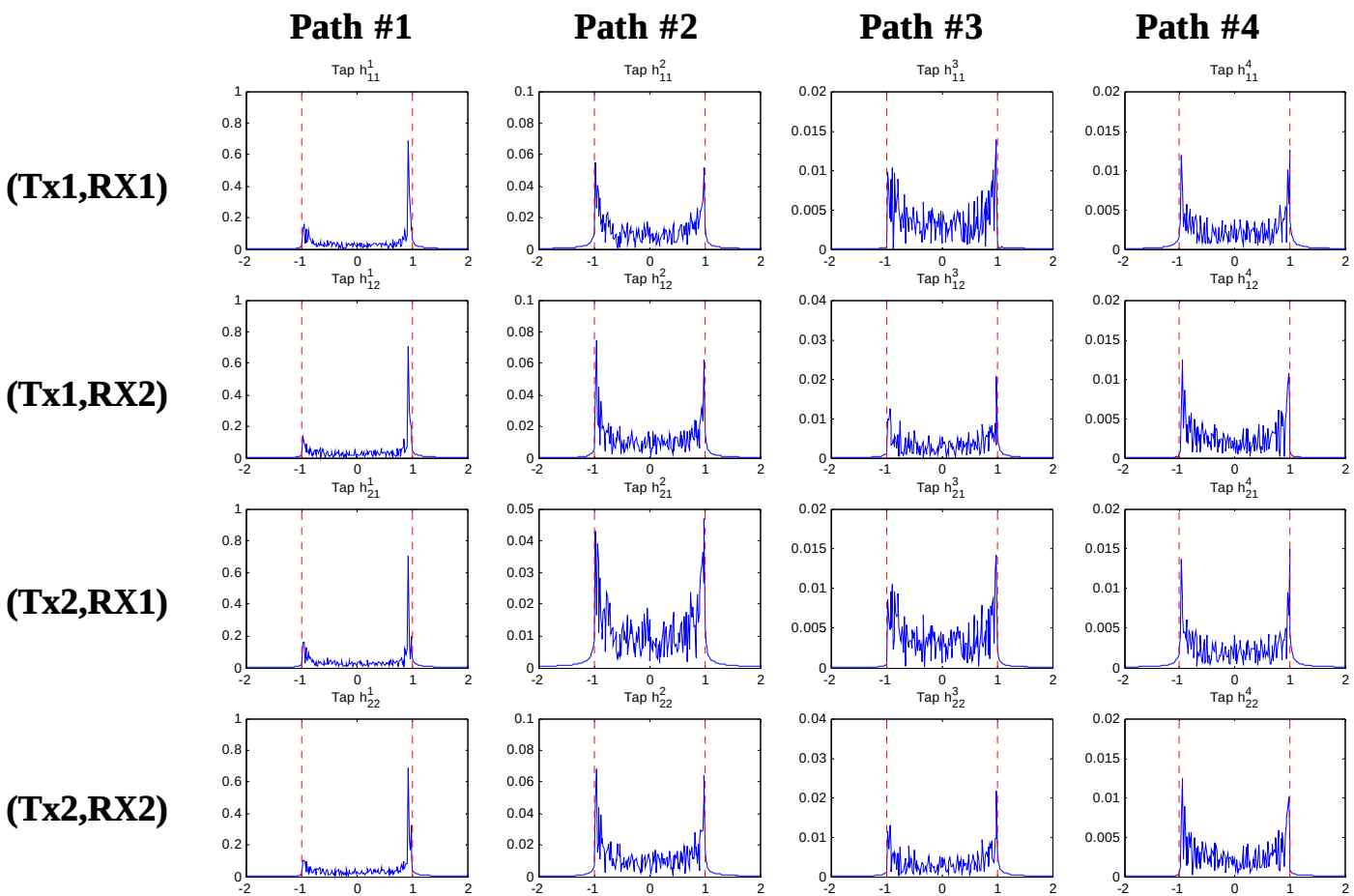






METRA Channel Model

METRA Model Case B (2TX-2RX) Doppler Spectrum



Conclusions

- MIMO system can achieve enormous capacity gain from multiple parallel sub-channels created in rich scattering environment.
- The METRA MIMO Model, based on the previous EC funded projects, is fairly realistic and easy-to-use with backward compatibility to ITU model.
- This model is currently being considered at 3GPP for MIMO channel model, and has been validated with actual experimental measurements.

References

[1] G.J. Foschini, M.J. Gans, “On limits of Wireless Communications in a Fading Environment when using Multiple Antennas,” *Wireless Personal Communications*, No. 6, 1998, pp.311-335

[2] J. P. Kermoal, L. Schumacher, K. I. Pedersen, P. E. Mogensen, and F. Frederiksen, “A Stochastic MIMO Radio Channel Model with Experimental Validation,” *IEEE JSAC*, vol. 20, pp. 1211-1225, Aug. 2002.

[3] L. Schumacher, J. P. Kermoal, F. Frederiksen, K. I. Pedersen, A. Algans, and P. E. Mogensen, “MIMO Channel Characterisation,” IST Project IST-1999-11729 METRA Deliverable D2, Feb. 2001

Appendix

Simulation Results using METRA MIMO Channel

- METRA Channel Case B (Ped. A) with speed = 60km / h
- MIMO OFDM System with AMC option of 16 QAM & r =1 / 2 LDPC code