Project	**IEEE 802.20 Working Group on Mobile Broadband Wireless Access** **<http://grouper.ieee.org/groups/802/20/>**
Title	**Channel Modeling for MBWA**
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Re:	MBWA Call for Contributions
Abstract	The contribution proposes a fundamental structure and concepts on spatial channel modeling that should be adopted for the evaluation of MBWA proposals.
Purpose	Discuss and Adopt
Notice	
Release	
Patent Policy	

Channel Modeling for MBWA

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Channel Model Requirements

- Accurately model a set of targeted channel environments (Macro/micro-cellular, Suburban/Urban, Outdoor/Indoor etc.)
- Capture the essential channel statistics
  - Temporal Characterization (Power Delay Profile)
  - Spatial Characterization (Power Azimuth Spectrum, Spatial correlations)
  - Realistic Doppler Spectrum
- Adopt a flexible approach to wideband modeling
- Channel Model definition should be conducted in a way that allows any type of antenna array configuration
- Channel Model should be tailored for system level evaluation (also link level analysis should be accommodated)

Channel Models & Proposal Evaluation

- System level performance metrics should be used as the basis for proposal evaluations.
- Adopt a realistic system level channel model:
  - Define Operating environment
  - A drop is assigned a spatio-temporal channel profile drawn from a continuous distribution (instead from a pre-determined set of fixed channels)
- Link level channel models can be drawn as realizations from the distributions for benchmarking purposes

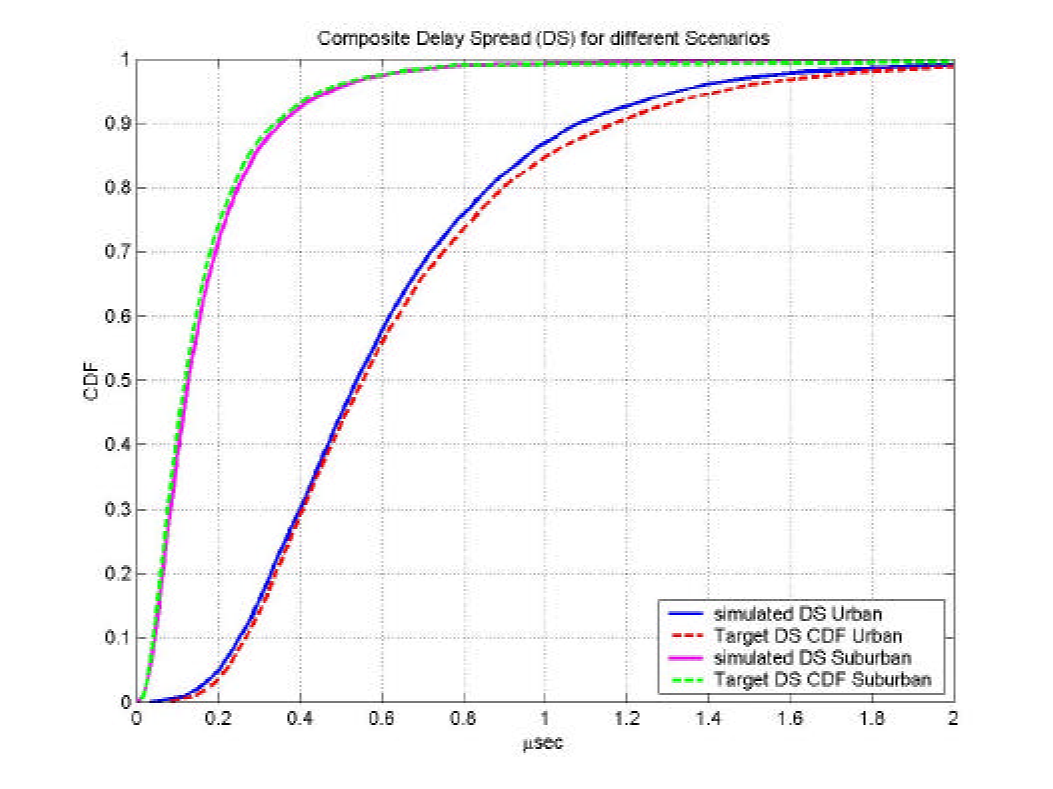
Channel Environments

- Channel model classification fromtypical environments (should be treated as common throughout a multi-cell layout) :
  - Macro-cells for large radius cells (e.g. 1-2Km). Also high antenna positions.
    - Suburban with low delay and angle spreads
    - Urban with moderate to high delay and angle spreads
    - Cases of clustered scatterers (bad urban or hilly terrain environments)
    - High range of mobile speeds
  - Micro-cells for small (urban) radius cells (e.g. 300-500m). Antenna height at rooftop or lower
    - High angle spreads and moderate delay spreads
    - Model sensitive to antenna height and scattering environment (dependence on street layout, line of sight effects)
  - The environment defines the temporal and spatial statistics as well as the pathloss model to be used

Temporal Characterization

- Accurate description of system behavior by per-drop realizations of the channel parameters out of distributions (rather than pre-determined finite set of choices)
- Measurement data show delay/angle spreads lognormaly distributed for macro-cells, [1]

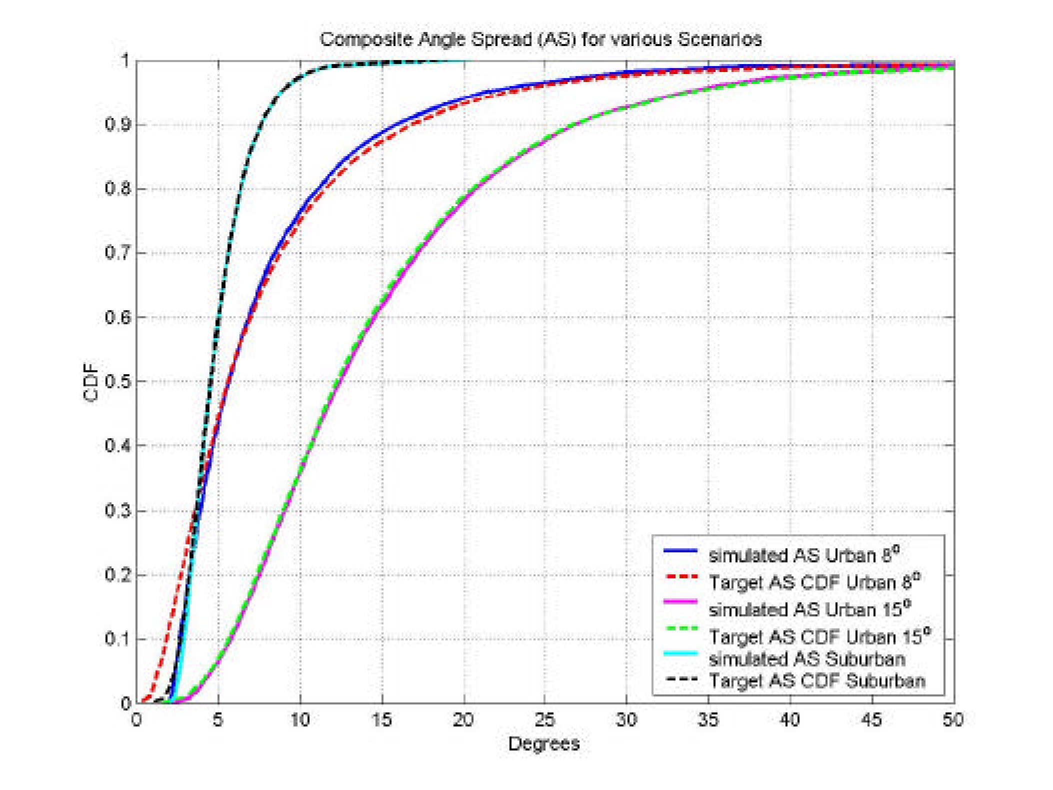
Example:
- Suburban and urban macro-cell Delay Spread (DS) distributions
- Target curves from measurements
- Simulated curves (solid) described by mean and variance



Spatial Characterization

- Narrowband rms angle spread distributions similarly described, [1]
- Should be characterized both at the base and at the mobile

Example:
- Suburban and urban macro-cell Angle Spread (AS) distributions at the base
- Target curves from measurements
- Simulated curves (solid) described by mean and variance



Parameter Dependencies

- Measurement campaigns indicate that the narrowband parameters are correlated (angle spread, delay spread, shadowing), [1]
- The narrowband parameters between cell sites may be correlated as well.

For macrocellular environments:
Angle Spread & Delay Spread: moderate-high positive correlation
Shadowing & Delay Spread: moderate-high negative correlation
Shadowing & Angle Spread: moderate-high negative correlation

Site-to-Site shadowing correlation: 0.5 (typical value)

WideBand Characterization

- A time-domain description of the wideband characteristics can be supported by a broad base of measurement data.
  - Clusters of scattering effects can be modeled by fading paths that have individual spatio-temporal parameters
  - Assign a finite set on N discrete paths induced by the scattering environment [4]
  - Every path is described by its own:
    - Relative delay and relative path power
    - Angle of Arrival (at base and mobile)
    - Power Azimuth Spectrum (at base and at mobile)
  - Resulting narrowband signal will have non-uniform power azimuth spectrum at the mobile.
  - Each path modeled by an ensemble of M waves (oscillators). The M waves emulate the desired PAS

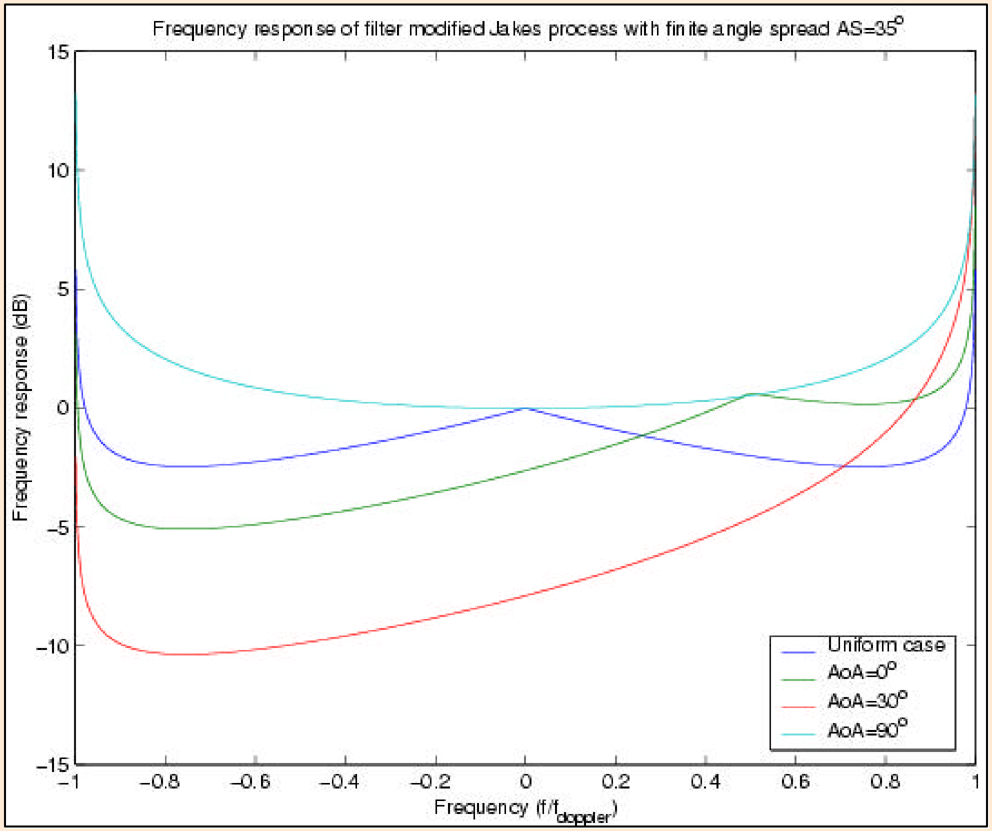
Wideband Characterization
(cont.)

- Most wideband parameters can be modeled to be consistent with measurement results
- Power Delay Profile follows well documented trends in macrocells
  - Path occurrence and path power decay exponentially in time, [3]
- Power Azimuth Spectrum at base also exhibits Laplacian decay (macrocells)
- Path AoA has been observed to be Gaussian distributed around the mean AoA of the narrowband signal at the base, [3]
- Further trends from measurement campaigns can be utilized to produce an accurate model of a wideband space-time channel

Doppler Spectrum

- Non-uniform PAS at the mobile
- Doppler Spectrum is affected by the PAS and the Angle of Arrival
- Doppler Spectrum affects the time-domain behavior of the channel. Should be accurately modeled

Example:
- Doppler spectrum from a signal with finite angle spread AS=35^0
-AOA defined with respect to mobile's speed vector

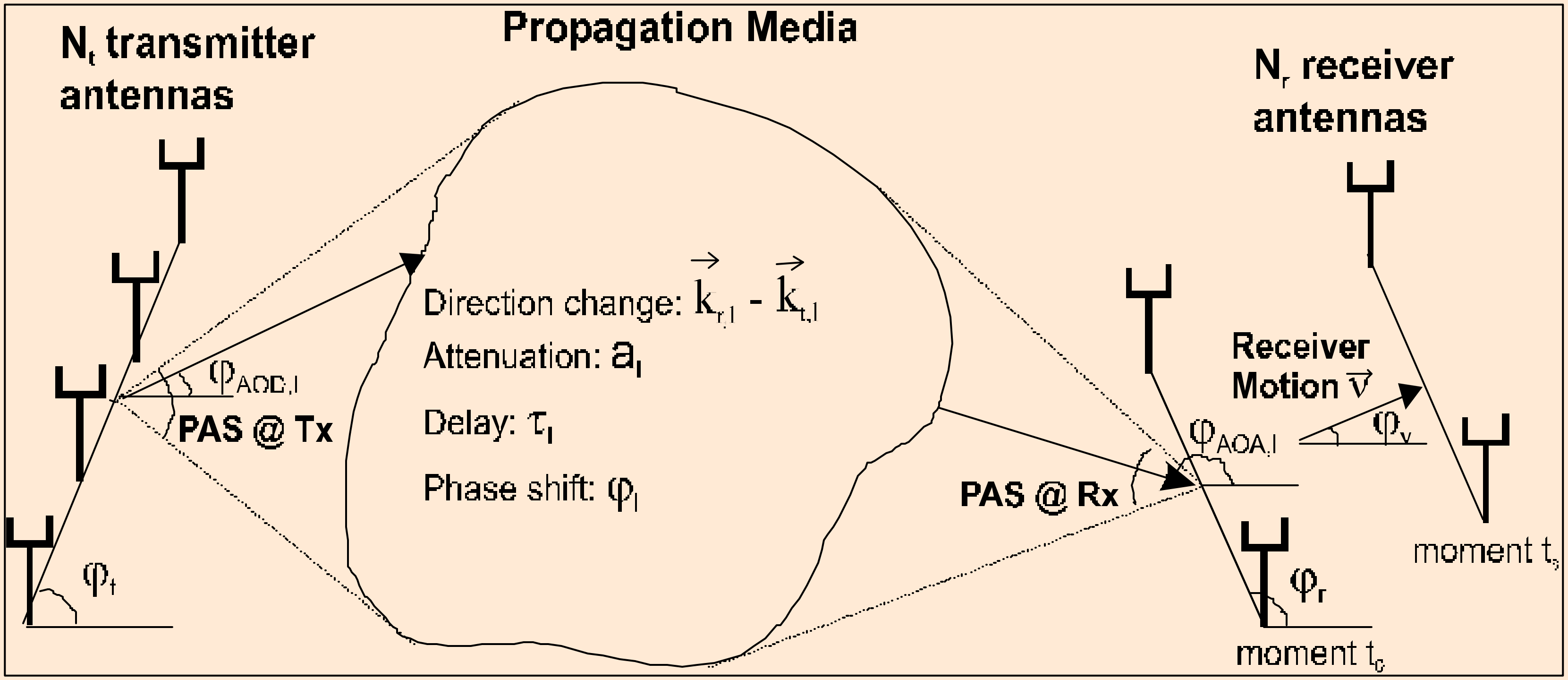


Model Implementation

- Wave-based model, [2]
  - Scatterers are abstractly located in the two dimensional space. Their impact at the base or mobile is abstractly determined by angle of arrivals, angle spreads, PAS, Power Delay profile.
  - Statistics and physical parameters from measurement data are directly usable here.
  - Captures all important wideband behaviors of the channel
  - Produces accurate channel realization
  - Accommodates any antenna array topology
  - Wave model inherently less complex than a geometrical-based model

- Low computational complexity is maintained
  - Channel model initialization is performed once per drop
  - Obtaining channel samples during a drop has same complexity to other similar methods

Wave-based model

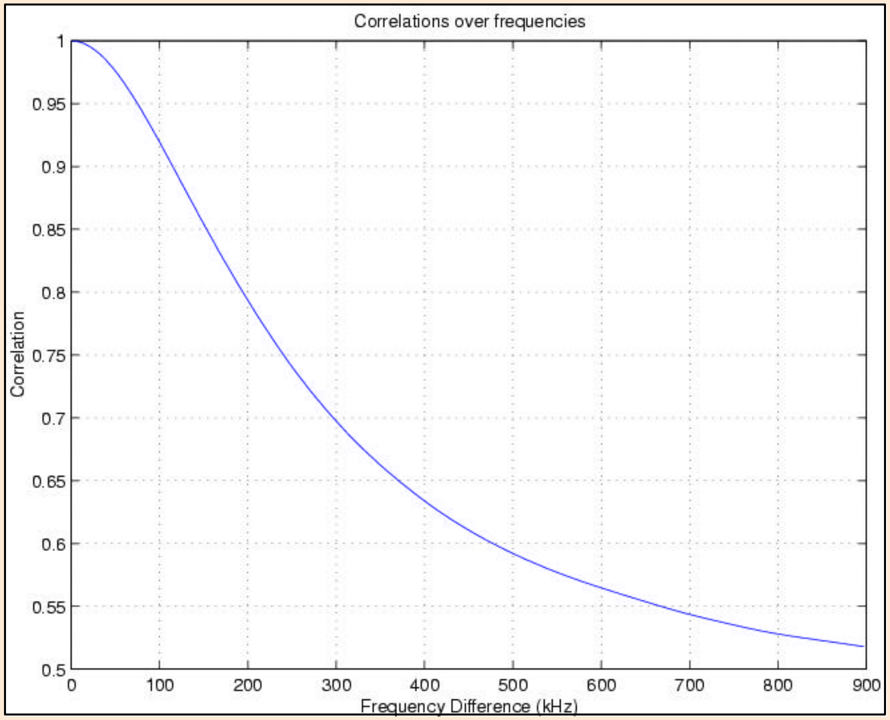


$$h_{n,m,q,s}^{NLOS} = \sqrt{P_q} \sum_{l=1}^{L} A_l \underbrace{\sqrt{P_{t,q}(\vec{k}_{t,l})}}_{PAS\ at\ Tx} \underbrace{\exp\{i\vec{k}_{t,l} \cdot \vec{d}_{t,m}\}}_{Phase\ due\ to\ Tx\ array} \underbrace{\sqrt{P_{r,q}(\vec{k}_{r,l})}}_{PAS\ at\ Rx} \underbrace{\exp\{i\vec{k}_{r,l} \cdot \vec{d}_{r,n,s}\}}_{Phase\ due\ to\ Rx\ array}$$

Frequency Domain

- For evaluation of OFDM-based interfaces the frequency selectivity can be extracted with Fourier transforms
  - FFT of the wave-based model into the frequency domain will be necessary
- Channel correlation over the frequencies becomes an important statistic of the model. Essential in physical layer design.

Example:
- Urban macro-cell with mean rms Delay Spread (DS) of 0.65μs
- Model simulation with N=6 paths



Summary

- Pursue accurate system level modeling with spatio-temporal distributions
- Develop a set of channel environments and parameter values for each
- Develop a detailed and flexible wideband model for capturing the essential channel statistics (in frequency and time domain)
- Channel model definitions should be made independent of the multi-element antenna techniques/architectures envisioned

References

- [1] A. Algans, K. I. Pedersen, P. Mogensen, “Experimental Analysis of the Joint Statistical Properties of Azimuth Spread, Delay Spread, and Shadow Fading,” IEEE Journal on Selected Areas in Communications, Vol. 20, No. 3, April 2002, pp. 523-531.
- [2] H. Xu, D. Chizhik, H. Huang and R. Valenzuela, "A Generalized Wideband MIMO Channel Model", PIMRC'2002, Lisbon, Portugal, Sept. 2002, also to appear in IEEE Transactions on Wireless Communications, 2003.
- [3] K. I. Pedersen, Mogensen and Fleury, “A Stochastic Model of the Temporal and Azimuthal Dispersion Seen at the Base Station in Outdoor Propagation Environments”, IEEE Trans. Vehicular Technology, vol. 49, No 2, March 2000, p. 437.
- [4] H. Boleski, D. Gesbert, A. J. Paulraj, “On the capacity of OFDM-based multi-antenna systems”, Proc. 2000 IEEE ICASSP, vol 5, p.2569.