Proposal for a Spatial Channel Model in 3GPP RAN1/RAN4

Contribution WG1#20(01)579 of Lucent Technologies to 3GPP-WG1
Busan, May 21st 2001
Basic Approach

† Implement the channel as an extended Jakes’ model
† Incorporate the recommendations of COST 259.
† Include spatial knowledge of the basestation, UE, and scatterer positions.
† Use a common set of scatterers for uplink and downlink.
† Include provisions for antenna patterns and mobile movement through the cell.
The contribution from each scatterer is summed to get the fading channel

\[ C(t) \approx \frac{E_o}{\sqrt{N}} \sum_k S_k(t) \]
Extended Jakes Model

\[ S_k(t) \sim G_b(b, k, f) e^{i \eta_k} \]

\[ G_m(m, k, f) \]

Base Station

\[ \vec{V} \]

Mobile

Scatterer

\[ \vec{V} \]

\[ i \frac{2\pi}{\lambda} d_{b,k} \cos(\theta_{b,k}) \]

\[ i \frac{2\pi}{\lambda} v \cos(\theta_{m,k}) t \]

\[ i \frac{2\pi}{\lambda} d_{m,k} \cos(\theta_{m,k}) \]
Goals of Spatial Channel Model

† Self-consistent modeling of:
  - Temporal Fading / Doppler Spread
  - Frequency Fading / Delay Spread
  - Spatial Fading / Angle Spread
  - i.e., cannot have arbitrary statistics
† Collapses to known 2-D model (e.g. Jake’s Model)
† Limited number of possible parameter assignments - repeatability!
† Self-consistent in both uplink and downlink channels (i.e. reciprocity while allowing for uplink/downlink frequency differences)
† Allows for time evolution (i.e., continuous from frame to frame)
  - useful in beam-steering performance evaluation
Relationship Between Scatterers and Parameters (1/2)

Scattering Cluster

Apparent Second cluster

UMTS 30.03 delay model limits the size of $d$ as well as the size of $D$

(for resolvability)
Doppler shift = \( \frac{v}{\cos(\theta)} \)

Angular distribution of illuminated scatterers relative to mobile velocity determines Doppler spectrum

Position of scatterers relative to receiver determines Angle-of-Arrival distribution
Options for Scatterer Distribution

† Options for Macro-cell models - scatterers around mobile:
  - uniform on circle about mobile
  - uniform in disk about mobile
  - uniform on spokes emanating from the mobile
  - Bivariate Gaussian about mobile

† Options for Micro-cell models - scatterers surround both mobile and base
  - uniform on circles about mobile and base
  - on ellipse with mobile and base at foci

† Each has its own AOA/TOA/Doppler statistics

† We have decided to ignore the TOA statistics within a cluster for macro-cell model assuming that each cluster is a single resolvable path (i.e., a UMTS 30.03 tap)
  - limits the cluster size
  - TOA statistics determine the number and size of the clusters
Macro-cell Models - Scatterer Distribution

Circle

Spoke

Disk

Gaussian
All macro cell distributions provide classic Doppler spectrum since they are uniform in angle about the mobile (assuming mobile uses omni-directional antenna and base station illuminates entire scattering radius)

Gaussian distribution matches best with limited AOA measurement data available

Thus, we choose Gaussian distribution of scatterers about mobile for macro/mid size cell model

Elliptical model allows separate scattering ellipses to represent different taps in UMTS 30.03 model

Other microcell models represent problematic relationships between AOA and TOA.

Thus, we choose Elliptical distribution of scatterers for micro-cell model
## Pedestrian

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<tr>
<th>Tap</th>
<th>Channel A</th>
<th>Channel B</th>
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<tbody>
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<td>Relative Delay (ns)</td>
<td>Average Power (dB)</td>
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## Vehicular

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<td>Relative Delay (ns)</td>
<td>Average Power (dB)</td>
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<td>-20.0</td>
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</table>
Example Scenario for Veh-A

~ 3-5 Km

? = 30m

WG1#20(01)579, Busan, May 21st 2001
**UMTS 30.03 Spatial Channel Models (1/2)**

† **Vehicular A**
- 6 clusters of scatterers (5 due to reflectors)
- each cluster bi-variate Gaussian - sigma = 30m
- cluster separations 90m - 750m
- mobile distance of 3-5km (macro cell)
- moderate/low delay spread (rms = 370 ns)
- low angle spread (rms = ~2 degrees)

† **Vehicular B**
- 6 clusters of scatterers (5 due to reflectors)
- each cluster bi-variate Gaussian - sigma = 40m
- cluster separations 90m - 6000m
- mobile distance of 3-5km (macro cell)
- high delay spread (rms = 4000 ns)
- low-moderate angle spread (rms = ~10 degrees)
UMTS 30.03 Spatial Channel Models (2/2)

- **Pedestrian A (Macro)**
  - 4 clusters of scatterers (3 due to reflectors)
  - each cluster bi-variate Gaussian - \( \sigma = 5m \)
  - cluster separations 35m - 125m
  - mobile distance of 300-500m (micro/mid cell)
  - low delay spread (rms = 45 ns)
  - low angle spread (rms = \( \approx 2 \) degrees)

- **Pedestrian B (Macro)**
  - 6 clusters of scatterers (5 due to reflectors)
  - each cluster bi-variate Gaussian - \( \sigma = 10m \)
  - cluster separations 60m - 1000m
  - distance of 300-500m (micro/mid cell)
  - moderate delay spread (rms = 750 ns)
  - moderate/high angle spread (rms = \( \approx 20 \) degrees)
The preceding model varies with time but does not account for larger scale movement of the mobile.

We may wish to examine the ability to track mobile movement (e.g., for beamforming).

To accomplish this we allow the scattering clusters to move at fixed intervals.

We add/delete scatterers by creating “composite distributions” to create overall Gaussian pdf.

The larger the time between changes the more the mobile moves and thus the more scatterers which will be added and deleted.

Increasing the number of scatterers to be changed increases the phase discontinuities experienced.
Super-position of Gaussians to produce a Gaussian
Model Validation

- Channel measurements were taken to aid in the creation of an appropriate channel model.
- Measurements taken in suburban (Whippany, NJ) and urban (Newark, NJ) settings. Whippany and Newark show moderate/narrow angle spread environments.
- Details of the measurement campaign results can be shared within 3GPP if a discussion forum is established.
- Sharing of channel sounding results within 3GPP is the only way forward for a realistic parameterization of the channel model.
References