Source: **Motorola**
Title: **Urban Canyon, and Parameter Values for the Spatial Channel Model**
Document for: **Discussion**

1. SUMMARY

A number of design approaches and parameter values are under discussion for the Spatial Channel Model, and this contribution investigates some of these approaches and the resulting parameter issues.

This contribution looks at additional details related to:

- Extending the urban canyon model, first presented in [1].
- Micro-cell parameter settings.
- Angle Spread, Delay Spread and r-value parameter settings.

2. URBAN CANYON MODEL FOR MACRO/MICRO-CELLS

Urban-canyons exist in dense urban areas served by Macro-cells, and in below-rooftop areas served by Micro-cells. Measurements presented in [1], and with further details in [2] illustrate the effects seen in a Macro-cell, which is characterized by a number of specific behaviors. This is shown in Figure 1, where there the AoA is described relative to the direction of travel of the measurement vehicle.

There are three distinct regions shown in the plot:

1) A large number of AoAs are present near 0 & 180 degrees, which are related to the path that arrives from the down the street direction, either in front or from the rear of the vehicle. The data is spread out over +/- 20^o in this region.

2) There is also a noticable number of cases that arrive in the range of +/- 90 degrees. This is indicative of locations near the intersection and over-rooftop paths.

3) The final region falls between these where there is a lower probability of seeing angles of arrival at various other angles.

Another effect is shown in Figure 2 representing the correlation between angles of arrival. The figure indicates that the probability is quite high for seeing paths from similar directions to the strongest ray path, but arriving in different time bins. Modeling this effect is very desirable, and can be accomplished using the CDF that is given which is a function of the ordered ray powers.

Since interfering paths originate from other directions, the AoA for a given interferer's strongest path is selected from the overall CDF of possible angles of arrival shown in Figure 1. Additional weaker rays are chosen with respect to the first. For example: When modeling interferer #1, the AoA of the strongest ray is chosen first irrespective of signals from other cells.

In order to match the statistics that the urban canyon exhibits, we propose the following model to be used to determine the subscriber mean AoAs of the six rays:

1. Pick a random direction of travel as a uniform random variable U(-180,180). This is going to be also the assumed street orientation.

2. Pick the AoA of the strongest ray in the channel impulse response according to the CDF depicted in Figure 1. A simplified curve fit will be given. Note that +/- angles are equally likely.

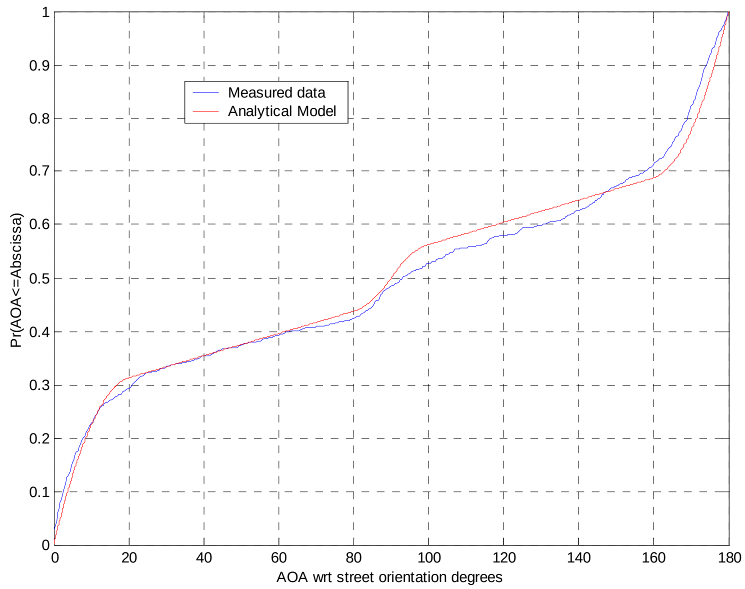

Figure 1 CDF of AoA wrt street orientation.

3. As shown in Figure , the AoA of the subsequent rays is highly correlated to the AoA of the first (strongest) ray. Therefore, pick the AoA for the subsequent rays in the channel impulse response according to the CDF shown in Figure 2. Notice that the weaker rays are less correlated to the main ray. Note also that the probability of finding a ray with AoA of $\pm 180^{o}$ is non-zero.

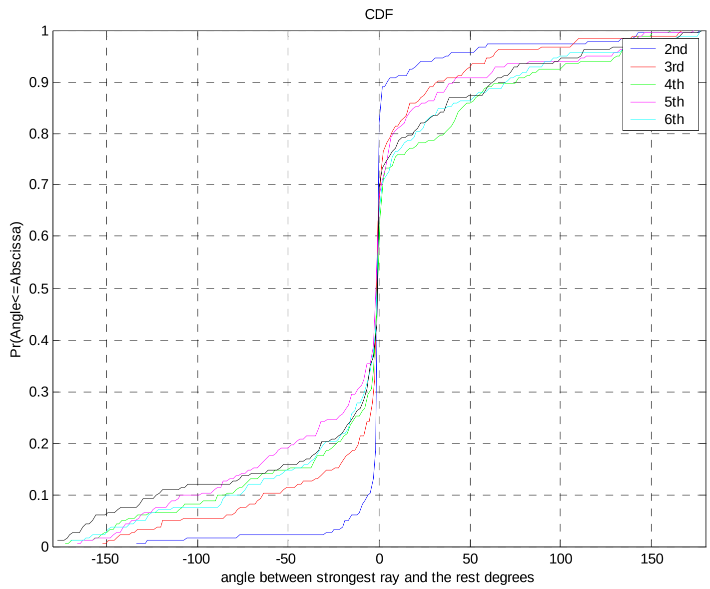

Figure 2, Angle Difference between the Strongest Ray and the remaining

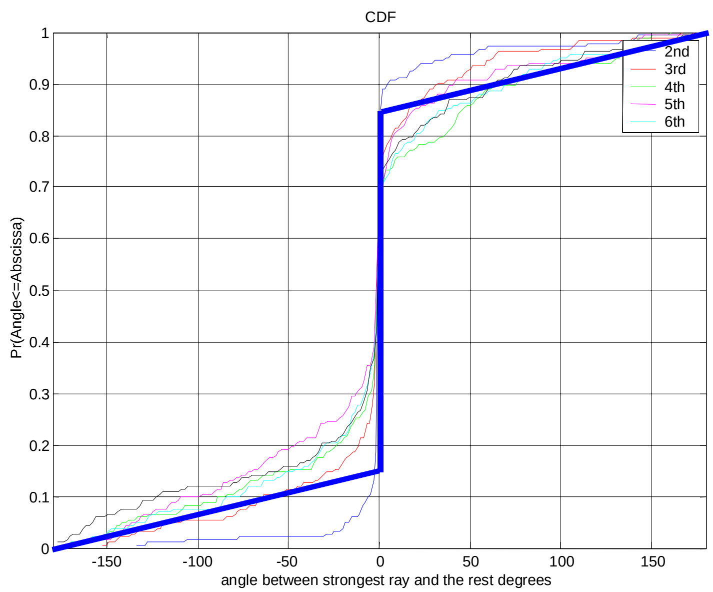

Figure 3 AoA Simplified CDF for the subsequent rays in the CIR

The CDFs that describe the angles between the strongest ray and the subsequent rays can be generated directly from Figure 2, or a simplified curve could be produced such as shown in Figure 3, to reduce the complexity of the model.

3. THE CASE FOR NO BUILDING GRID

Building grids, especially for Micro-cells constrain the environment to a site-specific situation. This is desirable for reproducing the effect of a given cell, however as a generic model using site specific environments are not very desirable.

There are a number of difficulties in applying a building grid model to either a Macro-cell or a Micro-cell and integrating it to the propagation model. The following items illustrate these difficulties, which are compounded in a spatial channel model.

Convergence: A complete description of the building grid parameters is required to insure it will converge to the proper average or X %-tile. A random or arbitrary set of buildings/streets is likely to converge to a unique set of performance values.

Repeatability: With a random assignment of propagation and spatial parameters to a building grid, it is not likely to be repeatable from run to run.

Properly sampling the environment space: In order to sample the environment adequately, all the potential propagation and spatial effects have to be available in the proper percentages. This includes a mix of streets, intersections, open areas, shadowed regions, etc.

Reproduce the proper propagation effects, spreads, path loss, log normal: A building grid must be mapped to a propagation parameter which combines propagation loss, log normal and spatial spreads. These effects should include correlation.

Layout: It is difficult to layout micro-cells to get the proper amount of coverage and isolation between interfering sites. Using a hexagon grid over a building grid will not represent a realistic micro-cell environment since actual cells are laid out in conjunction with the local environment and site specific clutter.

Use of a building grid requires all of these issues to be properly defined, and to physically have a large enough number of cases to be meet the statistical criteria. Clearly this is very difficult to achieve, and requires significant complexity.

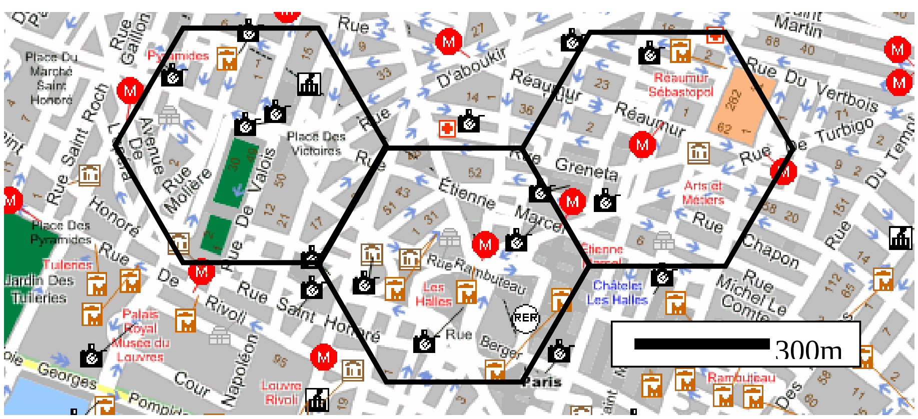

Figure 4, Example of Micro-cells in a Dense Urban Area (300m radius)

Figure 4 illustrates a dense urban area where 300m radius micro-cells are deployed. These are within the range of practical micro-cells depending on the height and method of installation. Note that there are not a large number of streets in these cells, which represent the locations from which subscribers can communicate. To properly sample the space and get statistical convergence, will be difficult to achieve with this type of a layout. For this reason, we propose the approach shown above which is statistical and requires no building grids.

Correlation between mobiles is currently ignored. If this effect is necessary, a model could be developed which chooses parameters for nearby mobiles in a correlated way.

4. PATH POWERS AND R-VALUES IN THE CURRENT SCM MODEL

Since a number of effects, including polarization BPR, are shown to be a function of the relative path power, it is important to insure the proper dynamic range and probability distribution of the path powers is obtained. In the following discussion, the path powers are shown to be a function of r_ds.

In the SCM procedure[3], care was taken to include the relationships between Angles and Powers, as well as Delays and Powers. This was done using the proportionality factors that were based on measurements. Specifically, for the Urban model a value of r_ds = 1.41, and r_as = 1.3 was chosen based on measurements[4]. The measurements from which the r-values were calculated included signal variation versus delay and angle, i.e. they were not monotonic. Thus they were equivalent to the case of the SCM model when noise is added to the monotonic envelopes specified for the Delay Spread and PAS.

When the SCM defined the Delay Spread model as a monotonic average envelope in terms of r_ds, the ability to produce a PAS with an arbitrarily defined r_as was constrained. In other words, the powers of the six rays are defined in terms of the delay spread envelope. When subsequently applying these powers to the Angle distribution to produce a PAS, the value of the powers do not produce the precise PAS envelope that is desired. This is likely due to the fact that the powers are selected to match the average envelope of a noisy signal profile, whereas the r-values were measured using noisy signal profile itself.

The consequence of the powers being set by the delay spread envelope and subsequently being applied to angles is to produce an angle spread that is effected directly by these powers. Further, varying the input value of r_as has no effect on the output r_as since its effect is to change the sigma of the angles at the Node-B, which effects both σ_{AoA} and σ_{PAS} by the same proportion. Thus r_as is only a function of the distribution of powers used, which is defined by r_ds.

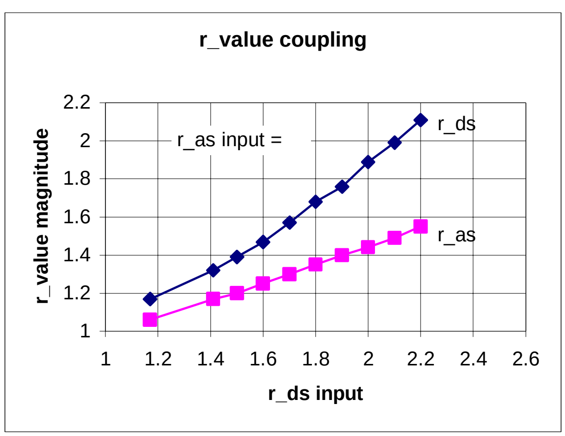

Figure 5, Analysis of r_value coupling

Figure 5 illustrates the effect of r_ds on the resulting r_as value. There is also a slight offset between the input and output r_ds, which is a consequence of only having a small number of rays. Note that the output r_as is independent of the input r_as. The problem with the current model is that the value of r_as cannot be set by the input parameter value (since it is only a function of r_ds,) and the current result is that r_as is too low to properly describe the spatial-power relationship of the channel.

Improvements to Parameter Selections:

To resolve this problem, an evaluation of parameter settings can be made to select values that are reasonable in both the time, angle, and power domains.

Measurements presented in [5] indicate that the r-values are sensitive to various measurement factors such as measurement thresholds. Values presented in [5] are summarized below:

	Threshold	15dB	20dB
Urban	r_ds =	1.78	2.35
Suburban	r_ds =	1.45	1.74

Table 1, Reported results from measurements

Table 1 indicates that measurements within a 15-20 dB threshold produce slightly higher r-values than previous data.

There is also a dynamic range issue to be considered. Use of average statistics restricts the possible path powers to a very limited range. The values shown below illustrate the restricted dynamic range of the powers, and the case for when the 4dB noise model is included.

R_ds	1%-tile Dyn range	1%-tile 4dB noise added
1.17	4 dB	19 dB
1.41	9 dB	21 dB
1.7	15 dB	25 dB
2.2	23 dB	31 dB

Table 2, Dynamic Ranges from selection of r_ds

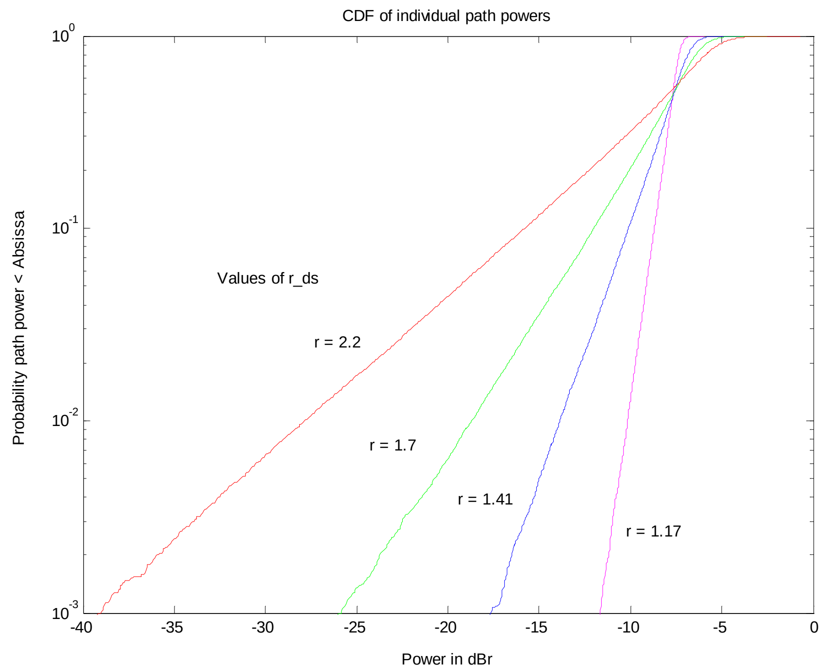

Figure 6, CDF of Normalized Path Powers

For several reasons, it is desirable to increase the values of r_ds.

- Places r_as in the proper ranges.
- Improves the dynamic range of the powers to be closer to measurements.
- For a given value of AS, the shape of PAS is more triangular, which is observed in measurements.

For the Urban example with r_ds = 1.41, a slight increase in the input value to 1.7 will produce the output values of: r_ds = 1.6, and r_as = 1.3. (1.3 was the target value for the r_as value)

For the Suburban example with r_ds = 1.17, a slight increase to 1.4 will produce output values of: r_ds = 1.32, and r_as = 1.18.

These new values are consistent with the numbers reported in [5] and shown above in Table 1.

To produce the variations seen in the channel, the noise model is required, as illustrated in Table 2.

5. CONCLUSION

In this contribution a number of items are described:

An extension to the urban canyon model is given which enables correlation between rays. It is evident that there is a high probability for paths to arrive from the same direction.

To implement an urban canyon model, it is suggested to use a statistical model rather than a building grid do to the complexities associated with properly accounting for: Propagation loss, Log Normals, Angle Spreads, Number of unique samples of the space, cell geometries, etc.

Regarding Path Powers, the dynamic range is severely limited for low values of the r-ratio. It is suggested based on looking at measurements, that the r-values need to be higher. This will: Improve the r_as values, dynamic range of the powers, and the shape of the PAS.

Values of r_ds = 1.7 for Urban and r_ds = 1.4 for Suburban are recommended. Also, to achieve realistic profiles of path powers, the noise model is required, else the ranges of path powers will not be realistic.

6. REFERENCES

[1] Motorola, “Polarization Modeling, Path Statistics & Urban Canyon Model,” SCM-064, Teleconference, October 10, 2002.

[2] Motorola, "Mobile Angle Spread Measurements and Angle Distribution Model", TSGR1#24(02)0408, Orlando, Florida, February 18-22, 2002.

[3] 3GPP – 3GPP2 SCM AHG Co-Editors, “Spatial Channel Model Text”, SCM-057, September 17, 2002.

[4] K. Pedersen, P. Morgensen, B. Fleury, “A Stochastic Model of the Temporal and Azimuthal Dispersion Seen at the Base Station in Outdoor Propagation Environments,” IEEE Transactions on Vehicular Technology, VOL. 49, NO.2, March 2000, pp.437-447.

[5] Qualcomm, “Standard Deviation of Delays versus RMS Delay Spread”, SCM-053, September 17, 2002.