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1 INTRODUCTION

The system-level spatial channel model is a rich and complicated topic both in breadth and depth. Because of its breadth, our discussions are at times confusing because successive contributions address entirely different aspects of the model. Because of its depth, it's very easy to get lost in the details of trying to capture all of the channel characteristics suggested by measurements. To address the "breadth" problem, we list the following three-step procedure for generating channel realizations based on our previous discussions:

Step 1. List parameters describing a given environment. The four environments are suburban macro, urban macro, urban micro, and suburban macro indoor/outdoor. We refer to these parameters as "environment parameters". In Section 2, we summarize the current environment parameters and propose values for those that have not been specified.

Step 2. For a given set of environment parameters, generate parameters for each user for a given drop. We refer to these parameters as "user parameters", and they include the RMS delay spread, composite angle spread, log normal fading, power delay profile and power azimuth spectrum. In Section 3, to address the "depth" problem, we propose a technique for generating user parameters that, we feel, achieves the proper balance among implementation ease, reflecting relevant measurements, and allowing for repeatability of system level results

Step 3. For a given set of user parameters, generate the time-varying channel realizations. One possibility is to use the wave model proposed in [1] and briefly described in Section 4.

2 ENVIRONMENT PARAMETERS

Table 1 below summarizes the parameters for the four environments. The starred items are proposed by Lucent, and all others are based on [2]. Note that parameters for "Urban micro" and "Suburban Macro Outdoor-Indoor" were not measured in a comparable way to the "Suburban Macro" and "Urban Macro". Unknown values are designated by "?".

Channel Scenario	**Suburban Macro**	**Urban Macro**	**Urban Micro**	**Suburban Macro Outdoor-Indoor**
Mean composite AS at BS	$E(\sigma_A)=8^0$	$E(\sigma_A)=8^0$	$*E(\sigma_A)=12^0$	$*E(\sigma_A)=12^0$
Composite AS at BS as a lognormal RV $\sigma_A=10^{\varepsilon_A x+\mu_A}$, x~N(0,1)	$\mu_A=0.84$ $\varepsilon_A=0.31$	$\mu_A=0.77$ $\varepsilon_A=0.37$	?	?
Per Path mean AS at BS	same as composite	same as composite	*same as composite	*same as composite
Per Path AS at BS as a lognormal RV	same as composite	same as composite	*same as composite	*same as composite
Per Path AoD distribution	$*U(-2.5\sigma_A,2.5\sigma_A)$	$*U(-2.5\sigma_A,2.5\sigma_A)$	$*U(-2.5\sigma_A,2.5\sigma_A)$	$*U(-2.5\sigma_A,2.5\sigma_A)$
Rms delay spread	$E(\sigma_D)=0.5$ μs	$E(\sigma_D)=0.9$ μs	$*E(\sigma_D)=0.5$ μs	$*E(\sigma_D)=0.5$ μs
Delay spread as a Lognormal RV $\sigma_D=10^{\varepsilon_D x+\mu_D}$, x~N(0,1)	$\mu_D=-6.40$ $\varepsilon_D=0.22$	$\mu_D=-6.13$ $\varepsilon_D=0.28$	?	?
Lognormal shadowing standard deviation	*8dB	*8dB	*8dB	*8dB
Composite AS at UE	$*\sigma_A=70^0$	$*\sigma_A=70^0$	$*\sigma_A=70^0$	$*\sigma_A=70^0$

Table 1. Environment parameters

For the per path AoD distribution, a uniform is assumed for simplicity (see Section 3.3), and the range from $-2.5\sigma_A$ to $2.5\sigma_A$ covers the majority of the power both theoretically and experimentally by [2]. The 8dB shadow fading standard deviation is a typical system level assumption. The values of 12^0 composite AS is adopted from the 3GPP2 channel model discussion. The 0.5 μs for microcell is adopted from COST 259. Finally, the composite AS at the UE is a deterministic value chosen based on narrowband measurements.

3 GENERATING USER PARAMETERS

The user parameters are defined per drop and are time invariant. They consist of the RMS delay spread (DS), composite angle spread (AS), log normal (LN) shadowing, power delay profile (PDP) and the power azimuth spectrum (PAS).

3.1 Generating DS, AS, and LNF

The DS, Node B AS , and LN are correlated lognormal random variables, and we assign a realization of each variable for a given user and a given drop. The realizations can be generated by the technique given in [2,3]. The UE AS is a deterministic quantity so it does not need to be generated.

Note from Table 1 the parameters for specifying the lognormal DS and AS random variables (m_D, e_D, m_A, e_A) are unavailable for the "Urban Micro" and "Outdoor-Indoor" cases. Obtaining these parameters would require an extensive measurement campaign that would delay timely release of the model. Therefore in absence of these parameters, we have two choices. The first is to remove "Urban Micro" and "Outdoor-Indoor" from the list of possible environments. The second is to model the DS and AS as deterministic quantities. The second option is not desirable because it does not sufficiently model the variability found in the real world. Therefore we suggest following the first option and remove "Urban Micro" and "Outdoor-Indoor" from the list of possible environments.

To further reduce the amount of system simulations, we suggest that the "Suburban Macro" environment also be removed for the following reasons. Since the DS and AS are random variables, the effect of the environment parameters is to change the distribution of these random variables. The AS distributions have significant overlap (because of the identical mean value of 8 degrees), and the "Urban Macro" has a higher mean RMS DS. Therefore by eliminating the "Suburban Macro" case, we are not sacrificing much richness with respect to AS, and we are getting a "lower bound" on performance because of the larger mean RMS DS. Also, by considering only a single environment, we are reducing the overall variability of the system parameters so that it will be easier to obtain reproducible system level results. Finally, HSDPA services will likely have more demand in "Urban Macro" environments, as reflected by the HSDPA single-antenna simulations.

In conclusion, we propose that only the "Urban Macro" environment be considered because of a lack of critical measurement data for some of the other channels, to reduce the overall system simulation load, and to allow for more easily reproducible system level results.

3.2 Generating PDP realization

Given the RMS DS and LN shadowing for a given user and drop generated in Section 3.1, we propose the following procedure for generating a realization of the PDP (as defined by the delays and average powers per path) with N = 6 distinct paths.

Step A: Assign N delays for each path: $t_1, \ldots, t_N$, with $t_1 = 0$. The interarrival time δ_n between the (n+1)-th and n-th paths is a random variable and is exponentially distributed with mean l :

$$p(d_n) = \frac{1}{l} e^{(-d_n / l)}, n = 1 \ldots N - 1$$

The parameter l is given an a priori value (which is independent of the realization) of $l = 0.91 \cdot s_{DS}$, where s_{DS} is the given RMS DS for this user.

Step B: Assign a mean power P_n for each generated path. The mean power of the path is an exponentially decaying function of the path delay given by

$$P_n = s_{LN} \frac{e^{(-t_n / m)}}{\sum_{n=1}^{N} e^{(-t_n / m)}}$$

where s_{LN} is the LN shadowing realization derived in Section 3.1 and m is given an a priori value (independent of the realization) of $m = 0.65 \cdot s_{DS}$. Note that the mean powers are normalized so that the total mean powers is $s_{LN} = \sum_{n=1}^{N} P_n$.

After the completion of Step B the resulting rms delay spread for this drop can be calculated. Note that the calculated RMS delay spread is a random variable itself. Figure 1 below plots the CDF of the calculated rms delay spread, and we note that the mean is s_{DS}.

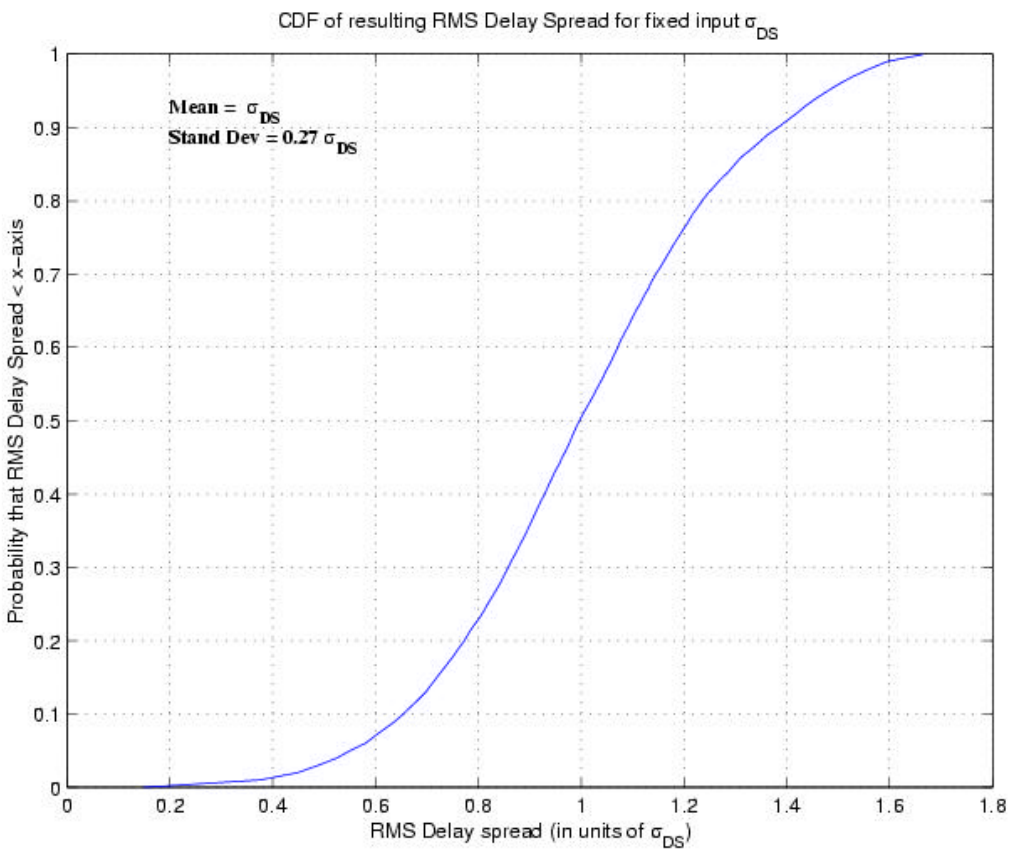

Figure 1. CDF of calculated RMS delay spread

3.3 Generating subpath mean powers and AoDs

Each of the N resolvable paths are composed of a M of subpaths. (In some SCM documents, the term ray is used in place of path; and subray, sinusoid, or wave is used in place of subpath.) Typically, M = 20. Given the composite AS and LN shadowing for a given user and drop generated in Section 3.1, we propose the following procedure for generating the mean powers and AoD of these subpaths.

Note that in measurements reported in [3], it has been shown that the joint power azimuth-delay spectrum can be decomposed as the product of the PAS and PDP distributions. Therefore, the PAS and PDP can be generated independently. Furthermore it is shown in [3] that the per path PAS may be generated according to the same statistics as the composite PAS.

Using these observations, we propose that for each path, the AoD of the M subpaths be drawn from a uniform distribution centered about the line-of-site (LOS) direction between the Node B and UE. The mean power of each subpath is weighted according to a Laplcian function so that the per path PAS (and hence the composite PAS) has a Laplacian distribution. As shown in [1], this approach can generate channel realizations with expected statistical properties.

More specifically, let q_0 denote the mean composite AoD as determined by the LOS direction from the Node B to the UE with respect to the Node B array broadside. The direction of the mth subray (m = 1 … M) for the nth path (n = 1 … N) is drawn from a uniform distribution:

$$q_{m,n} \sim U(q_0 - 2.5s_A, q_0 + 2.5s_A)$$

where s_A is the angle spread generated in Section 3.1 and the range is given by Table 1. The mean power of the mth subpath for the nth path is given by the Laplacian function

$$P_{m,n}(q_{m,n}) = \frac{P_n \exp(-\sqrt{2}\left|q_{m,n} - q_0\right| / s_A)}{\sum_{m=1}^{M} \exp(-\sqrt{2}\left|q_{m,n} - q_0\right| / s_A)}$$

where P_n is the mean power of the nth path derived in Section 3.2. The denominator is simply a normalization factor which insures that the sum of mean powers for the subpaths is equal to the mean power of the given path: $\sum_{m=1}^{M} P_{m,n}(q_{m,n}) = P_n$.

Note that this very simple procedure generates a Laplacian PAS with desired per path AS and component AS. Although Gaussian distributed AOA has been reported in [4] and proposed in [3], the Gaussian distribution is measured over several segments of a hundred wavelengths with approximately the same AS. Thus these measurements may not apply for the simulation methodology here, where the channel statistics are assumed static for each of the drop, and vary from drop to drop.

The technique described in this subsection is general and can also be applied to the UE for determining its subpath mean powers and AoAs. The difference is that the angle spread at the UE is a deterministic value set to s_A=70 degrees as given in Table 1, and the direction of the *m*th subray (*m* = 1 … *M*) for the *n*th path (*n* = 1 … *N*) is drawn from a narrower uniform distribution:

$$q_{m,n} \sim U(q_0 - 2s_A, q_0 + 2s_A) .$$

4 GENERATING CHANNEL REALIZATIONS

Given the path delays $t_1, \ldots, t_N$ from Section 3.2, the subpath AoDs (and AoAs) $q_{m,n}, n = 1 \ldots N, m = 1 \ldots M$ from Section 3.3, and the corresponding subpath mean powers $P_{m,n}(q_{m,n}), n = 1 \ldots N, m = 1 \ldots M$, we can derive the complex channel coefficient between a pair of transmit and receive antennas according to the wave model described in [1]. The subpath AoDs (AoAs) and mean powers need to be generated for each pair of antennas, but the path delays are independent of the antennas.

5 CONCLUSIONS

We have made the following proposals in this contribution:

1. Keep only the “Urban Macro” environment in order to simplify the system simulations.
2. Generate realizations of the path delay differences from an exponential distribution, and generate realizations of the mean path powers from a deterministic exponential function.
3. Generate the subpath AoDs from a uniform distribution, and generate the mean subpath powers from a deterministic Laplacian distribution.

We feel that the proposed techniques for generating the channel parameters are simple yet capture the most relevant characteristics of measured spatial channels.

6 REFERENCES

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