Mobile Channel Modeling for Evaluation of Multipath Components Parameters

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Abstract: This work presents an application of a geometry based model for the simulation of a common mobile telephony channel case. All critical parameters of the model are computed such as the Time-Of-Arrival (TOA), the Angle-Of-Arrival (AOA), the Angle-Of-Departure (AOD) and the received power of multipath components, in order to take decisions for using directional or smart antennas for fading reduction.

I. INTRODUCTION

Geometry based models, like the GBSBEM and GBSBCM [1, 2], which are suitable for urban and suburban or rural environments, respectively, present significant advantages over simple statistical and measurement based models. These are characterized by well defined assumptions which can always be compared against the specific environment for which the model is being applied and produce analytically tractable solutions for channel output parameters. In this work, a complete application of such a model is presented and the calculation of all critical parameters is performed for a characteristic test case including the critical scattering region (CR) [3] evaluation.

II. MODEL APPLICATION AND OUTPUT PARAMETERS EVALUATION

The GBSBEM (Geometrically Based Single Bounce Elliptical Model) is chosen for this application. In this case the scatterers are uniformly distributed inside an ellipse with foci at the Base Station (BS) and Mobile Station (MS). A Line of Sight (LoS) direct path always exists between the BS and MS, single bounce multipath is the dominant mode of propagation and all multipath components appear to arrive from the horizon [1]-[2]. Considering the downlink, in Fig.1 four scatterers are uniformly distributed inside the ellipse and critical parameters of the model are computed as shown in Table 1. It is assumed that the distance between BS and MS is D=1 km and only multipath components that have Time of Arrival (TOA) less than or equal to t_m = 5μsec are considered. Hence, the maximum excess delay would be τ_m = 1.667 μsec. Furthermore, the Power-Delay-Angle (pda) profile, the Power-Delay profile and the Power-Angle profile are presented respectively in Figs. 2 through 4. It is assumed that the transmitted power from the BS is P_T = 40W (46 dBm), omnidirectional antennas are deployed both at the BS and MS with gains G_T=8 dB and G_R=2 dB, respectively, the path loss exponent is n = 4, the loss due to the reflection from a scatterer is L_r=6dB and the carrier frequency is f= 900MHz.

Table 1. Critical parameters of the model

	AOA [Degrees]	AOD [Degrees]	Delay [μsec]	Power [dBm]
Line of Sight Component	0°	0°	0.0	-75.5060
1st Multipath Component	9.5335°	40.4807°	0.217	-82.6035
2nd Multipath omponent	-53.7745°	-23.8910°	0.801	-85.2475
3rd Multipath Component	79.8067°	20.6027°	1.195	-86.8279
4th Multipath Component	-47.9177°	-41.5706°	1.353	-87.4227

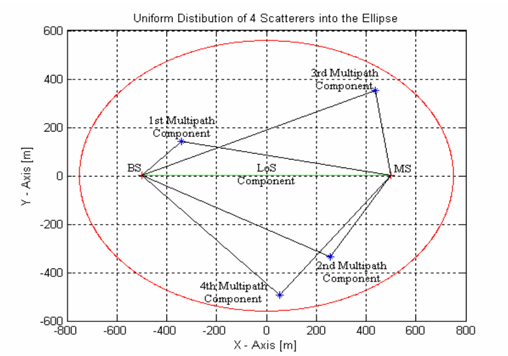

Fig. 1 Geometry of the model

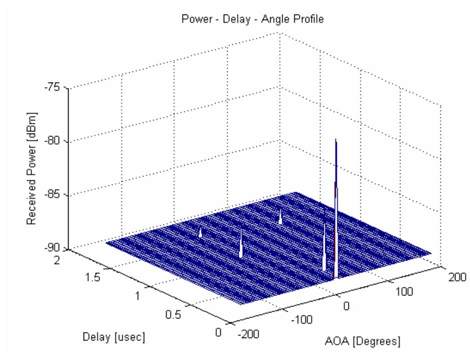

Fig. 2 Power-Delay-Angle profile

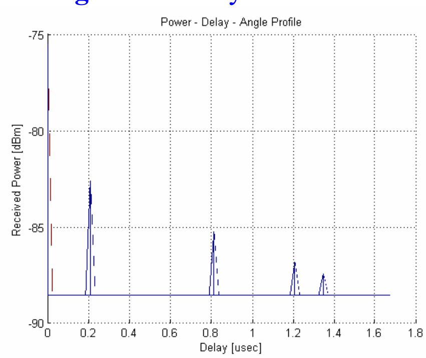

Fig. 3 Power-Delay profile

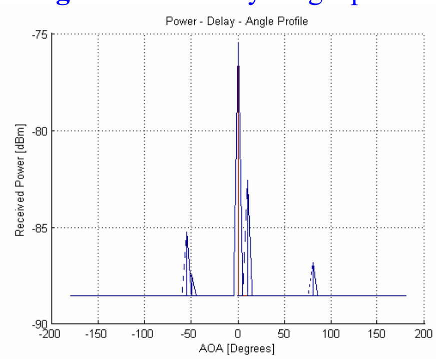

Fig. 4 Power-Angle profile

In order to validate the theoretical probability density functions (pdf) for the TOA and AOA (Angle of Arrival) [2], considering the downlink, 10000 scatterers are uniformly distributed into the ellipse and hence there are 10001 multipath components along with the LOS component. Fig. 5 shows the scatter plot of the computed TOAs and AOAs. The simulated pdfs are created by a histogram containing 75 bins. Both the theoretical pdfs and those which come from the simulations are normalized to unity as shown in Figs. 6 and 7 respectively.

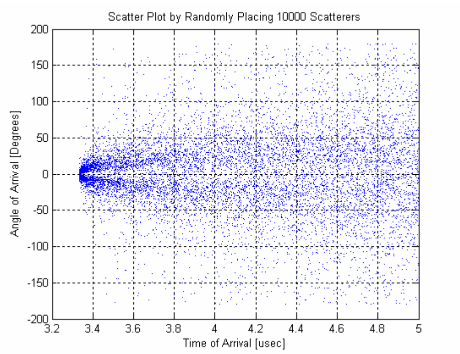

Fig. 5 Scatter plot

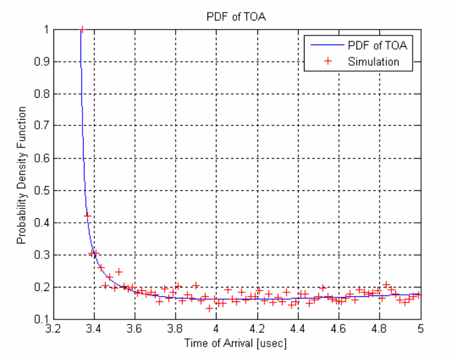

Fig. 6 pdf of TOA

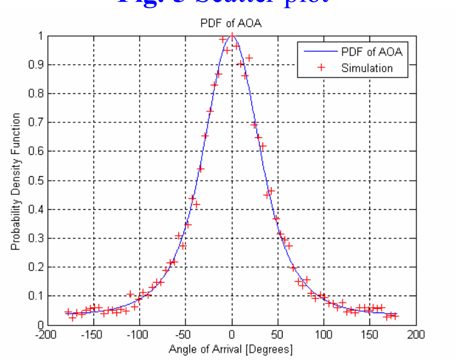

Fig. 7 pdf of AOA

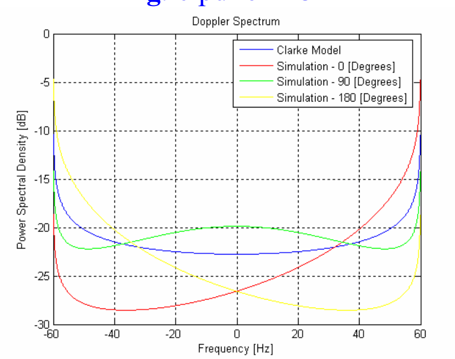

Fig. 8 Doppler power spectral density

Considering the Figs. 6 and 7, it is clearly shown that there is a very good matching between the theoretical and simulated pdfs of TOA and AOA.
Furthermore, in Fig. 8 the Doppler power spectral density at the MS [4]-[5] is presented, for a speed of mobile unit υ=72Km/h (20m/sec), which produces a maximum Doppler shift, f_m=60 Hz, for f=900 MHz. The MS is moving in a direction ϕ_v measured clockwise with respect to the LOS component between the BS and MS. Three cases were taken: i) $\phi_v = 0^o$ (the MS is moving towards to the BS following the direct path), ii) $\phi_v = 90^o$ (the MS is moving perpendicular to the BS), iii) $\phi_v = 180^o$ (the MS is moving away from the BS following the imaginable line of the direct path). The other plot, Clarke's model, corresponds to the classical Doppler power spectral density.

The critical scattering region [3], presented in Fig. 9, is useful in order to estimate the theoretical rates of multipath reduction. It is defined as that region of scatterers whose multipath's TOA and AOA are simultaneously within the intervals defined as $\overline{\tau}-\sigma_\tau \le \tau \le \overline{\tau}+\sigma_\tau$ and $\overline{\theta}-\sigma_\theta \le \theta \le \overline{\theta}+\sigma_\theta$.
The first equation defines an elliptical belt whereas the second one defines an angular scattering region. Furthermore, three probabilities are defined as: p_1 is the probability to find a scatterer inside the elliptical belt, p_2 is the probability to find a scatterer inside the angular scattering region and p_3 is the probability that a scatterer belongs to the critical scattering region. Considering the uplink, 10000 scatterers are uniformly distributed into the ellipse.
Simulation gives the following results: mean TOA $\overline{\tau}$=4.074 μsec, standard deviation σ_τ = 0.5202 μsec, mean AOA $\overline{\theta}$=0^o due to symmetry and standard

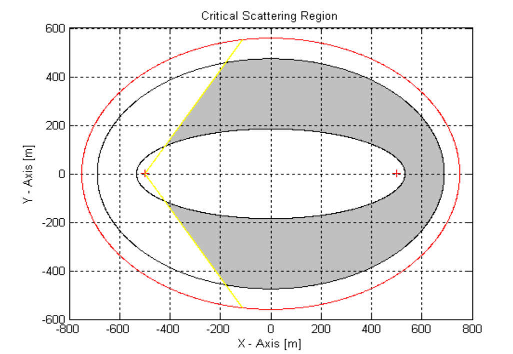

Fig. 9 Critical scattering region

deviation σ_θ=54.977º. The probabilities described above are respectively: p_1 = 0.544, p_2=0.758 and p_3=0.400. Probability p_3 implies that if the BS can adjust its antenna's aperture to the Angle Spread (AS) $=2\sigma_\theta$ and the Delay Spread (DS)=$2\sigma_\tau$, then it would be possible to cancel the 59.99% of multipath components.

III. Conclusions

In this paper a demonstration of the GBSBEM application for a GSM-900 test case was shown. The critical output parameters were computed, Power-Delay-Angle profile was created and validation of the probability density functions of TOA and AOA was done. Furthermore, the Doppler power spectral density was presented and the critical scattering region was calculated. From the AOA and AOD model output information, investigation of the ability to reduce fading by using a kind of smart antennas can be performed.

References

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