Source: **Motorola**
Title: **Far Scattering Cluster**
Document for: **Discussion**

1. SUMMARY

The Far-Scattering (FS) model as described in [1], is an important model for describing cases where a non-uniform environment produces a set of delayed paths with specific power and angle relationships. This case is often considered to represent a bad-urban environment [2]. It is likely that this case should also be used to model suburban areas, which often have late rays produced by buildings, terrain, or environment features, although the SCM currently doesn't include FS for the suburban case.

- The Far-Scattering model is implemented with parameter value assumptions
- Examples are given for validation purposes

From discussions of a recent contribution in the last SCM Ad-hoc meeting [3], it was identified that the model proposed in [4] would not properly consider the reverse link reception at the base, since the Far Scattering Cluster should be common among numerous mobiles in the sector. To account for this the FSC model was redesigned by the group. It was agreed to have 3 Far scattering clusters in the serving cell, randomly located uniformly across the hexagon. The far scatterer closest to each mobile would then be visible to that mobile and used in the path calculations.

2. FAR-SCATTERING MODEL FOR MACRO-CELLS

The improved Far-Scattering model is documented here with a description of the parameters and steps to implement the model within the SCM. This description is based on the discussions in the previous SCM Ad-hoc, and illustrates the technique of applying the 3 FS clusters per cell and choosing the closest one to the mobile.

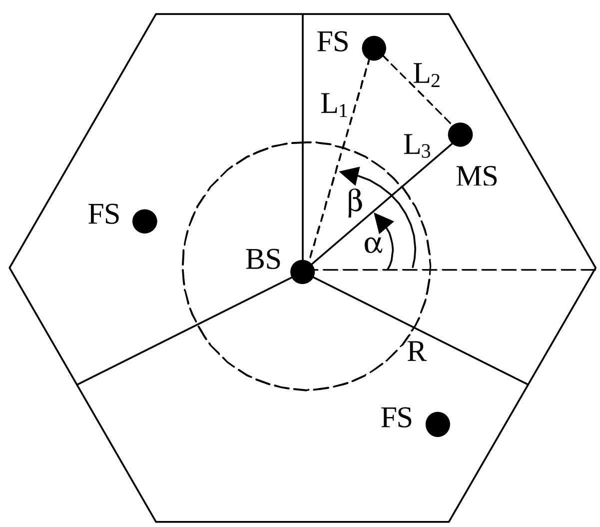

Figure 1, Far-Scattering Cluster Geometry

Figure 1 describes the geometry associated with the far-scattering model that was discussed in the previous SCM Ad-hoc.

R = Minimum Radius beyond which the far-scattering cluster may be located.
FS = Location of the far-scattering cluster
MS = Subscriber location
BS = Base station location
L1 = Distance between BS and FS
L2 = Distance between FS and MS
L3 = Distance between BS and MS
α = angle to the MS
β = angle to the FS

The geometry shown in Figure 1 is used to define several of the parameter values. Four multi-path components are associated with L3 which is the line-of-sight path to the MS. The composite base angle spread associated with the NLOS propagation model will have an average AoD in the direction of α, and the individual AoDs are chosen from a Gaussian distribution defined by the SCM model. For the two paths associated with the far-scatterer, a Gaussian AoD distribution is assumed with a sigma equal to the average value for the SCM model, i.e. either 8˚ or 15˚.

The path with the shortest delay cannot be less than the time required to travel the line-of-sight distance from the base to mobile. (The SCM does not define the first path at time $\tau = 0$ to be a LOS path, but this is assumed here as a reference unless an excess path delay is specified.)

The excess delay of the path to the far-scatterer will be the delta path delay between the far-scatterer path and the BS to MS path. $L_1 + L_2$ = path distance from BS to MS via the far-scatterer. The delta distance will be: Excess Distance = $L_1 + L_2 - L_3$. Therefore the excess delay is obtained by dividing the distance by C, the speed of light.

Excess Path Delay $\tau_{excess} = (L_1 + L_2 - L_3)/C$

Three far-scatterers are located geometrically in the cell beyond the minimum distance R=500m using uniformly random locations within the cell. To avoid biasing the geographic cell, the FS clusters that affects the path of the mobile is chosen so that the one closer to the mobile is used, and the others are ignored by that mobile. This approach makes use of FS clusters in adjacent sectors when they are closer to the mobile than the FS cluster in the geographic cell. In this model, three far-scatterers are used, independent of the BS antenna configuration or the number of sectors.

The shadow fading has been described to be common among all paths of the same cluster, and independent between clusters. The site-to-site correlation of 50% applies to this situation since the environmental characteristics near the mobile are common to both paths.

The modified procedure in detail is:

1. Drop MS within test cell as usual.

2. Drop three FS clusters uniformly across the cell hexagon, with a minimum radius of R = 500m.

3. Choose the FS cluster to use for the mobile that is closest to the mobile.

4. Generate 6 delays

$\tau_1, \tau_2, \tau_3, \tau_4, \tau_5, \tau_6$

5. Sort $\tau_1,\ldots,\tau_4$ into increasing delays,

6. Subtract shortest delay of $\tau_1,\ldots,\tau_4$ from each of $\tau_1,\ldots,\tau_4$

7. Sort τ_5, τ_6 into increasing delays,

8. Subtract shortest delay of τ_5, τ_6 from each of τ_5, τ_6

9. Assign Powers to paths corresponding to all 6 delays:

$P_n^{'} = e^{\frac{(1-r_{DS})\cdot\tau_n}{r_{DS}\cdot\sigma_{DS}}} \cdot 10^{-\xi_n}$, $n = 1,\ldots,6$ where ξ_n $(n = 1,\ldots,6)$ are i.i.d. Gaussian random variables with variance $\sigma_{RND}^2 = (3\text{ dB})^2$.

10. Calculate excess path delay τ_{excess} and add to τ_5 and τ_6.

11. Attenuate P_5 and P_6 by 1dB/uS of excess delay with a 10dB maximum attenuation.

12. Include proper shadow fading deltas between clusters.

13. Normalize powers of the 6 paths to unity power.

In the following plots, simulation results are shown to illustrate the behavior of the far scattering cluster when it is added to the standard SCM model.

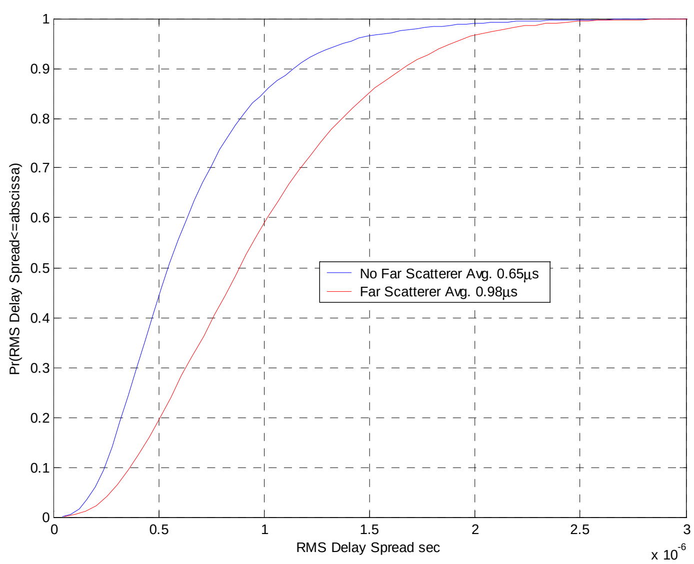

Figure 2, Delay Spread with a Far-Scattering Cluster

Figure 2 describes the distribution of simulated delay spread. When the Far Scatterer is added to the model with its extra path length, the delay spread is increased accordingly. The average value increases from the 0.65µS for the No-FS case to 0.98µS for the FS case.

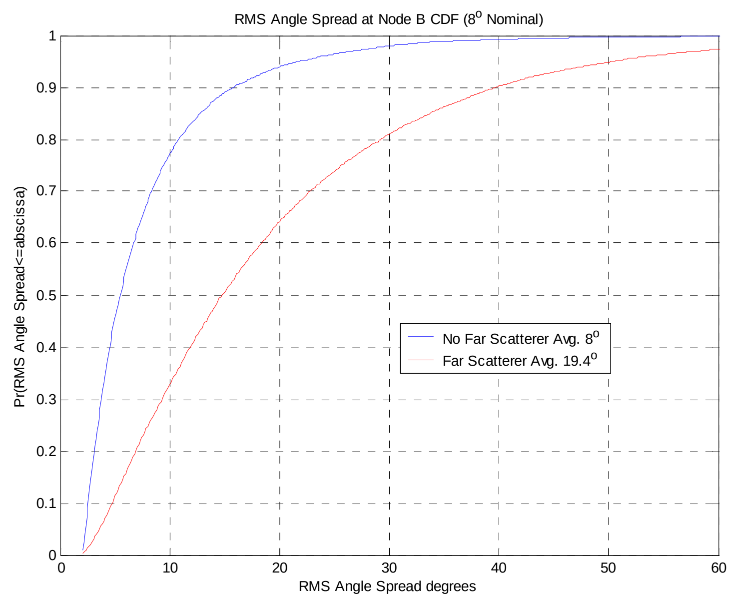

Figure 3, Composite Base Angle Spread with a Far Scattering Cluster (8º nominal)

Figure 3 describes the composite base angle spread when the FS cluster is added for the case when the AS = 8º. There is an increase in angle spread caused by the relative angle difference and the powers associated with the signals arriving from the later cluster.

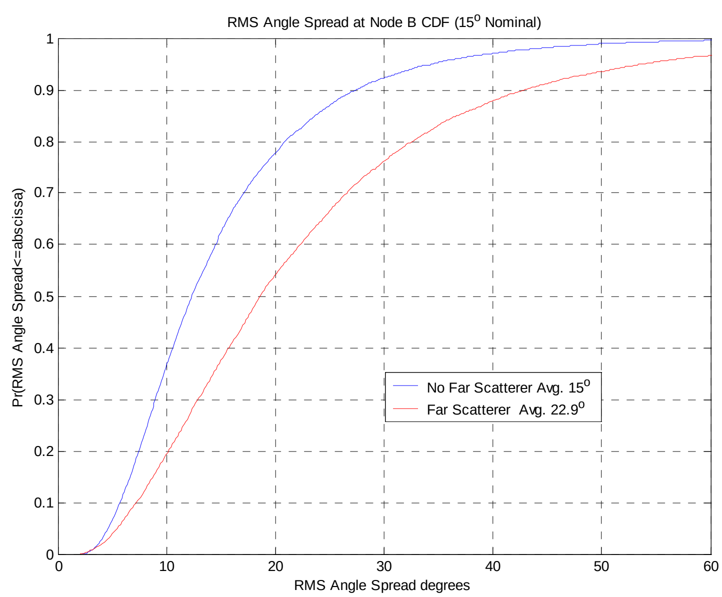

Figure 4, Composite Base Angle Spread with a Far Scattering Cluster (15º nominal)

Figure 4 describes the composite base angle spread when the FS cluster is added to the model for the case when the AS = 15º. There is an increase in angle spread caused by the relative angle difference and the powers associated with the signals arriving from the later cluster.

For these experiments the test mobile was confined to the geographic sector, however the sector may be a best serving sector for mobiles that are outside the geographic sector boundary. For simplicity this is not included in distributions shown the plots.

3. CONCLUSION

Details are given to describe the FS cluster operation. The model is based on a redesign of the basic assumptions that occurred during the last SCM Ad-hoc meeting. In the new design, three FS clusters are applied uniformly across the cell, and the mobile has visibility to only the closest FS cluster.

This approach of specifying the FS cluster does not overly emphasize the geographic sector, but allows the active FS cluster to be in the adjacent sector a fraction of the time thus allowing different sectors or different cells to have a statistically fair chance to be the best server.

Also as desired, the reverse link reception can experience a FS cluster that is common to multiple mobiles.

4. REFERENCES

[1] Mitsubishi Electric Research Lab, SCM-072, “Open Questions on the MIMO Channel Model”, Quebec City, October 22nd , 2002.

[2] L. M. Correia, Wireless Flexible Personalized Communications, COST 259: European Co-operation in Mobile Radio Research, Chichester: John Wiley & Sons, 2001.

[3] SCM Co-chair, SCM-113, “Conference Call Summary”, Teleconference, Feb 13, 2003.

[4] Motorola, SCM-109, “Far Scattering Clusters”, Teleconference, Feb 13, 2003.