Generation of LSP

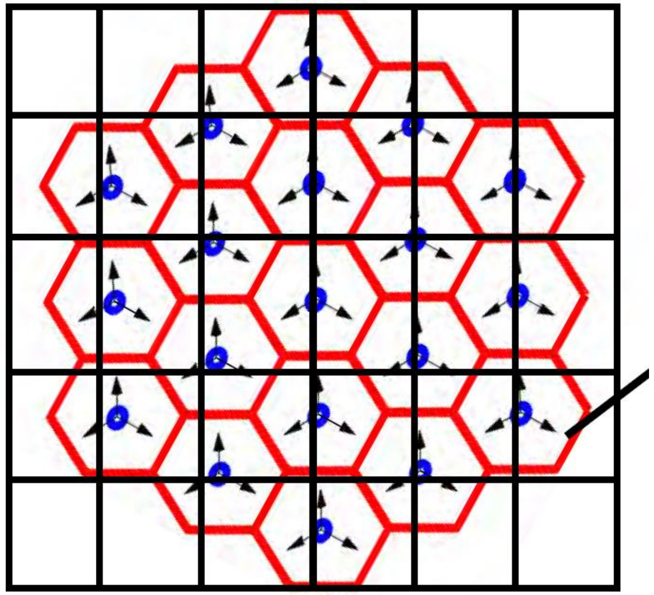
Documents to reference

- Step 1, 8~9
  - WINNER II D1.1.2 V1.2 page 33

- Step 3~6
  - Efficient modelling of channel maps with correlated shadow fading in mobile radio system

Step1 : LSP Map size and Grid interval

- Determine LSP Map size and Grid interval.
- Map size is slightly larger than layout size. (For interpolation)
- Grid interval is arbitrary. (In Vienna, 10m)



Step2 : map generation

- Based on the size of the grid determined in Step 1, generate a map to store LSP.

- The number of maps to be generated depends on the number of Bs, the number of Floor, LOS NLOS OUT2IN, and the number of Large Scale Parameter(LSP), depending on each environment.

Ex) For Uma, Bs = 19, Floor = 8, LSP = 7 for LOS, LSP = 6 for NLOS OUT2IN (except K factor for NLOS and OUT2IN)

Step3 : Correlation Matrix R generation

- Correlation Matrix R is generated according to the number of adjacent nodes to be considered as follows.
- $r(\delta) = e^{-\delta/\Delta_m}$
  - δ = Grid node interval,
  - Δ_m= correlation distance (eval.document Table 4-7~4-12)

$$\mathbf{R}_5 = \begin{pmatrix} 1 & r(\delta) & r(2\delta) & r(\delta) & r(\sqrt{2}\delta) \\ r(\delta) & 1 & r(\delta) & r(\sqrt{2}\delta) & r(\delta) \\ r(2\delta) & r(\delta) & 1 & r(\sqrt{5}\delta) & r(\sqrt{2}\delta) \\ r(\delta) & r(\sqrt{2}\delta) & r(\sqrt{5}\delta) & 1 & r(\delta) \\ r(\sqrt{2}\delta) & r(\delta) & r(\sqrt{2}\delta) & r(\delta) & 1 \end{pmatrix},$$

- Four neighbors case

$$\mathbf{R}_9 = \begin{pmatrix} 1 & r(\delta) & r(2\delta) & r(\delta) & r(\delta) & \dots \\ r(\delta) & 1 & r(\delta) & r(\sqrt{2}\delta) & r(\sqrt{2}\delta) & \dots \\ r(2\delta) & r(\delta) & 1 & r(\sqrt{5}\delta) & r(\sqrt{5}\delta) & \dots \\ r(\delta) & r(\sqrt{2}\delta) & r(\sqrt{5}\delta) & 1 & r(2\delta) & \dots \\ r(\delta) & r(\sqrt{2}\delta) & r(\sqrt{5}\delta) & r(2\delta) & 1 & \dots \\ r(\sqrt{5}\delta) & r(\sqrt{2}\delta) & r(\delta) & r(\sqrt{8}\delta) & r(2\delta) & \dots \\ r(\delta) & r(2\delta) & r(3\delta) & r(\sqrt{2}\delta) & r(\sqrt{2}\delta) & \dots \\ r(\delta 3) & r(2\delta) & r(\delta) & r(\sqrt{10}\delta) & r(\sqrt{10}\delta) & \dots \\ r(\sqrt{2}\delta) & r(\delta) & r(\sqrt{2}\delta) & r(\delta) & r(\sqrt{5}\delta) & \dots \end{pmatrix}$$

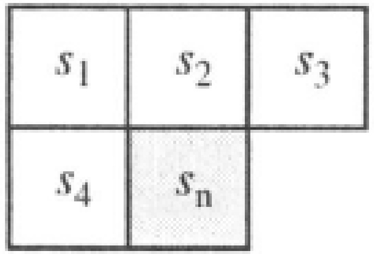
$$\begin{pmatrix} \dots & r(\sqrt{5}\delta) & r(\delta) & r(3\delta) & r(\sqrt{2}\delta) \\ \dots & r(\sqrt{2}\delta) & r(2\delta) & r(2\delta) & r(\delta) \\ \dots & r(\delta) & r(3\delta) & r(\delta) & r(\sqrt{2}\delta) \\ \dots & r(\sqrt{8}\delta) & r(\sqrt{2}\delta) & r(\sqrt{10}\delta) & r\delta \\ \dots & r(2\delta) & r(\sqrt{2}\delta) & r(\sqrt{10}\delta) & r(\sqrt{5}\delta) \\ \dots & 1 & r(\sqrt{10}\delta) & r(\sqrt{2}\delta) & r(\sqrt{5}\delta) \\ \dots & r(\sqrt{10}\delta) & 1 & r(4\delta) & r(\sqrt{5}\delta) \\ \dots & r(\sqrt{2}\delta) & r(4\delta) & 1 & r(\sqrt{5}\delta) \\ \dots & r(\sqrt{5}\delta) & r(\sqrt{5}\delta) & r(\sqrt{5}\delta) & 1 \end{pmatrix}. \quad (15)$$

- eight neighbors case

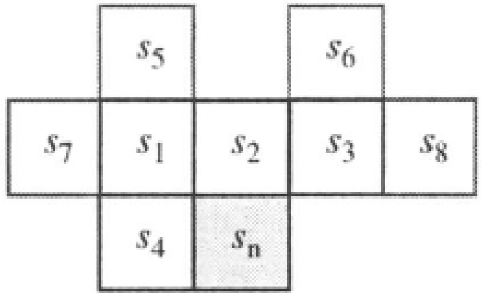
Step4 : $\tilde{L}^{-1}$, $\tilde{s}$, λ_n^T setting

- $\tilde{R}$ = matrix with the last row and column of R reduced by 1.
- $\tilde{L}$ = $cholesky\ decompositon\ of\ \tilde{R}$
- $\tilde{s}$ = vector of correlated RN value of adjacent nodes (ex) 4-neighbor case $\tilde{s} = \{s_1, s_2, s_3, s_4\}$
- λ_n^T = The bottom row of R
- In case of $\tilde{s}$, there may be insufficient number in the map edge part. In this case, only possible neighbor nodes are used.

  - Need to use another R, so use other things which is changed together. In the case of Vienna, the value of the neighboring node that does not exist is set to 0 and R is used as it is.



Adjacent node deployment of four neighbors case



Adjacent node deployment of eight neighbors case

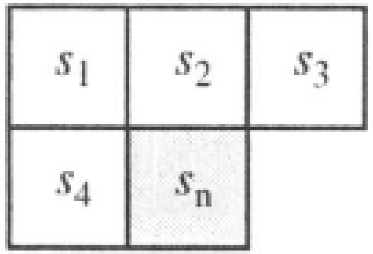
Step5 : Gaussian Random Number generation

- Generate uncorrelated Gaussian Random Numbers~ N(0,1) in each grid node of the map.

Step6 : Auto-correlation generation

- Apply the following equations to each node.
- a_n = Gaussian R.N generated from n node

$$s_n = \lambda_n^T \begin{bmatrix} \widetilde{\mathbf{L}}^{-1}\tilde{\mathbf{s}} \\ a_n \end{bmatrix}$$



Adjacent node deployment of four neighbors case

Step7 : Interpolation

- Interpolation is used to obtain the value of the correlated RN at the actual UE location.
- We are currently considering which interpolation method to use.

Step8 : application of cross-correlation

$$\tilde{\mathbf{s}}(x_k, y_k) = \sqrt{\mathbf{C}_{MxM}(0)}\,\boldsymbol{\xi}_M(x_k, y_k)$$

$$\mathbf{C}_{MxM}(0) = \begin{bmatrix} C_{\tilde{s}_1\tilde{s}_1}(0) & \cdots & C_{\tilde{s}_1\tilde{s}_M}(0) \\ \vdots & \ddots & \vdots \\ C_{\tilde{s}_M\tilde{s}_1}(0) & \cdots & C_{\tilde{s}_M\tilde{s}_M}(0) \end{bmatrix}$$

- $C_{MxM}(0)$: matrix based on eval.document Table 4-7~4-12 Cross-Correlation
- $\sqrt{C_{MxM}(0)}$: $cholesky\ decompositon$ of $C_{MxM}(0)$
- $\xi_M(x_k, y_k)$: Auto-correlated LSP vector
- $\tilde{s}(x_k, y_k)$: TLSP vector

Step9 : LSP generation

- Convert TLSPs to LSPs by applying appropriate transforms for each parameter.

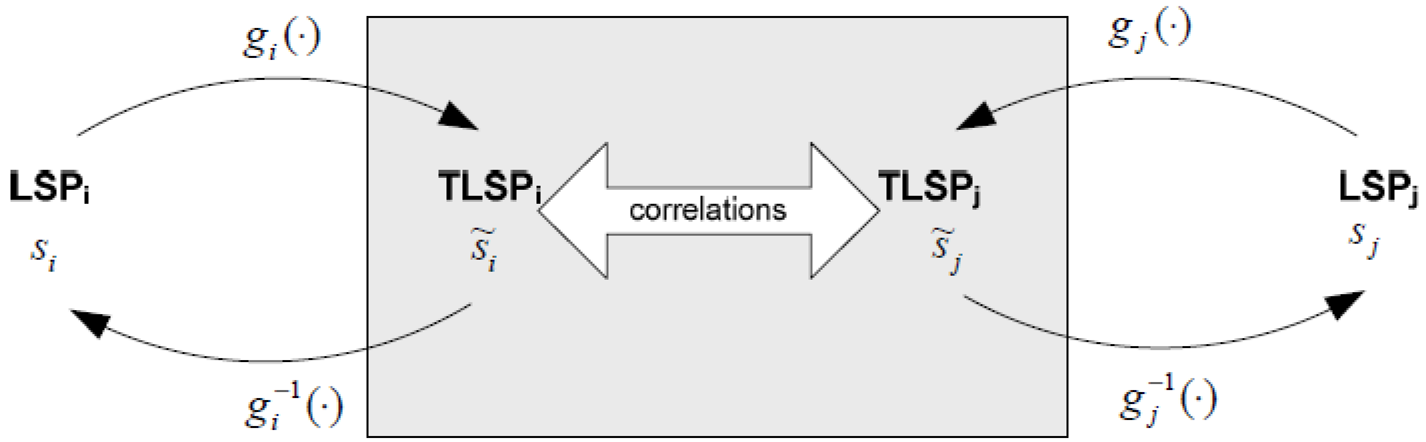


Figure 3-7 Correlations of LSP are introduced in transformed domain.