Agenda Item:

Source: Siemens[1]

Title: Time variant simulation parameters for Tx diversity using correlated antennas

Document for: Discussion

Introduction

For Tx diversity simulations that investigate using more than 2 antennas a time varying channel has not been defined yet. This contribution describes simulation parameters to model a time varying channel. The model is based on an updated covariance matrix *R* corresponding to the propagation environment in which the UE is moving. The covariance matrix *R* was already used for the static, partially correlated channel model in [1, 2].

The goal of the simulations set by this model is to check the capability of the TxD system to follow the changing long-term channel statistics. Also, the influence of feedback errors in the long-term feedback can be evaluated.

In the first section we propose a simple trajectory of the UE within the cell. This is then used for subsequent calculations in the next section. In section 3 the recommended simulation parameters are listed for macro cell and micro cell scenarios as well as the case of uncorrelated antennas.

1 Trajectory of the UE

To introduce long-term time variant channel characteristics the following approach is proposed: The UE intersects the cell on a simple trajectory with constant velocity as shown in Figure 1.

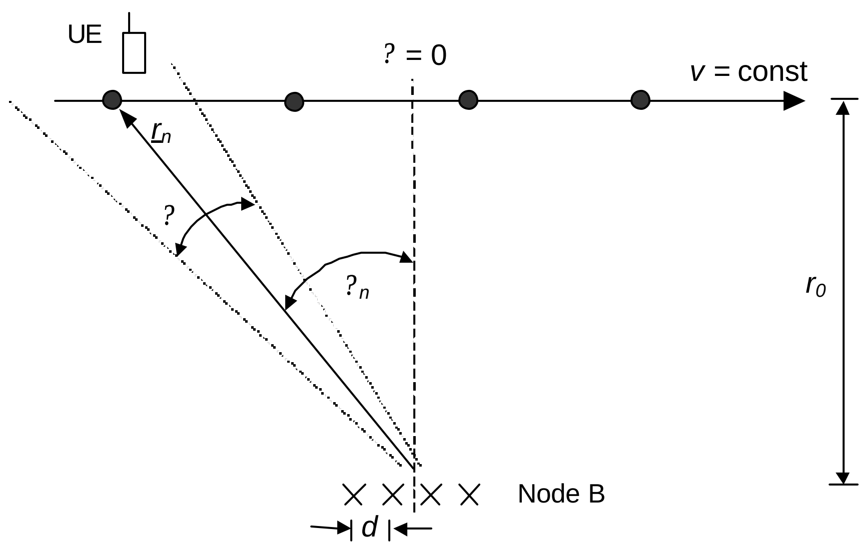

Fig. 1: Cell Geometry

[1] In cooperation with the Institute for Circuit Theory and Signal Processing of Technische Universität München, Germany

We parameterize the trajectory by means of *N* equal time segments, thus the location of the UE at each step can be described by

$$\underline{r}_n \; ? \; \begin{matrix} ? s_n ? \\ ? \\ ? r_0 ? \end{matrix}, \qquad (1)$$

where $s_n \; ? \; vn?t$. The parameter *v* denotes the velocity, whereas $?t$ is the time resolution of the model. It should be of the order of 100 ms. The time index *n* is in the range of $n \; ? \; ? \frac{N}{2} ? 1, ? \frac{N}{2}, \square \;, \frac{N}{2} ? 1, \frac{N}{2}$ (with *N* even). The time covered by the simulation is $T \; ? \; ?t \; N$.

The direction $?$ of the center of the path can be calculated as:

$$?_n \; ? \; \arctan \begin{matrix} ? \\ ? \\ ? \end{matrix} \frac{s_n}{r_0} \begin{matrix} ? \\ ? \\ ? \end{matrix} \qquad (2)$$

In the scenario local scattering around the UE is assumed. This results in an angular spread of the sub-paths regarded as planar waves of the Node B received at the UE. The angular spread is denoted by $?$ and assumed to be constant during the simulation. This is necessary in order to achieve characteristic simulation results linked to the amount of correlation between the antennas.

2 Calculation of the instantaneous covariance matrix

The covariance matrix *R* is used to model the partial correlation of the antenna elements as can be seen in [1]. With the now time varying case the matrix *R* is updated in each time step *n* with respect to the direction $?_n$ to the UE. The sub-paths received at the UE are assumed to be uniformly distributed on the angular region $?$. Similar to [1] the covariance matrix can be written as

$$R_n \; ? \; \frac{1}{Q} \overset{Q/2}{\underset{q??Q/2}{?}} \underline{a}(?_{q,n})\, \underline{a}(?_{q,n})^H , \qquad (3)$$

where for the assumed uniform linear antenna array (ULA) with *M* = 4 antenna elements the steering vector $\underline{a}$ equals to

$$\underline{a}(?_{q,n}) \; ? \; \tfrac{1}{2} (?^0, ?^1, ?^2, ?^3)^T \text{, with} \qquad (4)$$

$$? \;\; ? \; \exp(j2? \tfrac{d}{?} \sin ?_{q,n}) \; ? \; \exp(j? \sin ?_{q,n}) \qquad (5)$$

In Equation (5) an antenna spacing of d = $?/2$ was used.

The angle $?_{q,n}$ of the sub-paths is described by:

$$?_{q,n} \; ? \; ?_n \; ? \; \frac{q}{Q} ? \qquad (6)$$

The number of sub-paths *Q* can be a value greater than the number of antenna elements, e.g. *Q* = 10 or *Q* = 100.

3 Parameters for different propagation environments

3.1 Macro cell (rural area)

This scenario consists of a large cell with a UE in relatively large distance to the Node B. The paths of the planar waves are uniformly distributed on an angular spread of 10°. Note, that the simulation time *T* should be chosen such that $?_n$, the direction to the UE, does not exceed ? 45°, since the distance of the UE to the Node B gets too large (e.g. for a speed of 120 km/h the maximum value for *T* is 120 s)

The recommended parameters for this case are summarised in Table 1:

Distance r_0 from Node B to UE	2000 m
Angular spread ?	10°
Channel model(s) and UE velocities	1-path Rayleigh: 3, 10, 40, 120 km/h Modified ITU Veh. A: 10, 40, 120 km/h
CL feedback error rate (long term and short term)	4 %
Number of sub-paths Q	10

Table 1: Parameters for macro cell environment

3.2 Micro cell (urban area)

In this scenario a smaller distance between the UE and the Node B is assumed. For each time instant the planar waves are uniformly distributed on an angular region of 45°. Note, that the simulation time *T* should be chosen such that $?_n$, the direction to the UE, does not exceed ? 45°, since the distance of the UE to the Node B gets too large (e.g. for a speed of 40 km/h the maximum value for *T* is 90 s)

The recommended parameters for this case are summarised in Table 2:

Distance r_0 from Node B to UE	500 m
Angular spread ?	45°
Channel model and UE velocities	Modified ITU Ped A: 3, 10, 40 km/h
CL feedback error rate (long term and short term)	4 %
Number of sub-paths Q	100

Table 2: Parameters for micro cell environment

3.3 Uncorrelated case

Here, the covariance matrix *R* is modeled to be the same for all time instances. The extreme case of uncorrelated antennas is used (refer to [3]).

$$R_n ? \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

The modified ITU Ped A model (velocity 3, 10, 40 km/h) is used for the delay path.

4 References

[1] Siemens, "Simulation parameters for Tx diversity simulations using correlated antennas", Tdoc R1-00-1180

[2] Siemens, "Channel model for Tx diversity simulations using correlated antennas", Tdoc R1-00-1067

[3] Nokia, "Recommended simulation parameters for Tx diversity simulations", Tdoc R1-00-0867

[4] Siemens, "Advanced closed loop Tx diversity concept (eigenbeamformer)", Tdoc R1-00-0853