MATLAB implementation

of the

3GPP Spatial Channel Model Extended (SCME)

Implementation Documentation

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Requires MATLAB 6.5.0 (R13) or later

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Table of Contents

1. Introduction

This document describes a MATLAB implementation of the Interim Channel Model for Beyond-3G Systems [SCME], denoted SCME as it is an extension of the 3GPP Spatial Channel Model (SCM) [SCM]. Note that this SCM extension is not associated with the 3GPP working group. It was developed in Workpackage 5 (WP5) of the WINNER[1] project [WIN] of the European Union's 6th Framework Program. Also note that SCME is different to the WINNER interim (WIMi) or final channel model (WIM) corresponding to the WINNER deliverables D5.3 and D5.4, respectively.

The work documented in this report has also been in most parts carried out in Workpackage 5 (WP5) of WINNER. Previously, this group has already implemented SCM as [SCMI], which is the basis of this extension.

This document describes only the additions and modifications to the original SCM code. The SCME-package furthermore includes:

1. the extended/modified SCM MATLAB code
2. the documentation from the [SCMI] package

The software was developed for MATLAB 6.5.0 (R13). Older MATLAB versions may cause unexpected problems. Certain optional ANSI-C functions require GNU Scientific Library (GSL), but the program can also be used without it. Details of the MATLAB code, MATLAB package installation, and usage information are described in 2.

2. Extension features

The SCME contains the following additional features compared to SCM:

- Intra-cluster delay-spread
- 5 GHz path-loss
- Line-of-sight (LOS) and K-factor model in all scenarios
- Time-variant shadow fading
- Time-variant angles and delays
- Reduced-variability TDL model

These features are described in detail in [SCME]. The additional MATLAB parameters are summarized in Table 2.

Table 1: Addition to MATLAB struct SCMPAR

Parameter name	Definition	Default value
`IntraClusterDsUsed`	Switch for intra-cluster delay-spread.	'no'
`FixedPdpUsed`	Switch for fixed power delay profile.	'no'
`FixedAnglesUsed`	Switch for fixed angles.	'no'
`DriftShadowFading`	Switch for time-variant shadow fading.	'no'
`DriftDelaysAngles`	Switch for time-variant delays and angles.	'no'
`AlternativePathloss`	Switch for alternative path-loss model.	'no'

Table 2: Modified return values of functions.

Note that parameter `SCMPAR.XpdIndependentPower` is in SCM, but not in the SCME.

In the following, we give a brief description and usage information on each of the features. Some features provide additional input and output parameters, which are also discussed.

[1] Wireless World Initiative New Radio

2.1 Intra-cluster delay-spread

Introducing intra cluster delay spread increases effective bandwidth of the model. Twenty subpaths of the basic SCM are grouped to three (macrocells) or four (microcells) midpaths with different delays causing about 10 ns intra cluster RMS delay spread. The delays are fixed and listed in [SCME].

This feature can be switched on by setting `SCMPAR.IntraClusterDsUsed = 'yes'`.

2.2 5 GHz path-loss model

The parameter `SCMPAR.PathLossModel` (default value `'pathloss'`) specifies the MATLAB function used for path-loss calculation. It is possible to use some other path-loss models by giving the function name to `SCMPAR.PathLossModel` or by modifying `pathloss.m`.

There are two path-loss models in SCME: the default long-range path-loss model equivalent to the one defined in SCM, and a new alternative shorter-range path-loss model. The alternative path-loss model can be selected by setting `SCMPAR.AlternativePathloss` to `'yes'`. The frequency extension to 5 GHz is applied equivalently in both models.

The program selects the path-loss model frequency (2 or 5 GHz) by evaluating the parameter `SCMPAR.CenterFrequency`. If `SCMPAR.CenterFrequency` is closer to 5 GHz, an offset of +8 dB is added to the path-loss.

2.3 LOS and K-factor model in all scenarios

As with the basic SCM, the LOS option is activated by setting `SCMPAR.ScmOptions` to `'los'`. The LOS option affects the parameters path-loss and shadow variance. The choice between LOS and NLOS within a "drop" is based on the probability of LOS versus distance. This probability function is defined in SCME for macro scenarios and in SCM for the micro scenario.

With the alternative path-loss model, LOS option is now defined in all scenarios. In the default (SCM) path-loss model, LOS option is defined only for the urban micro scenario. If LOS is selected anyway in this case, path-loss values and shadow variance are taken from the urban micro LOS scenario and a warning is shown.

A K-factor model is now also available in all scenarios and it is active if the current "drop" is LOS. The K-factor model in suburban and urban macro was set to the suburban model from [SCME].

2.4 Time-variant shadow fading

Each "drop" consists of `SCMPAR.NumTimeSamples` time samples a.k.a. channel snapshots. In the basic SCM, the shadow fading is constant during a drop. In this extended version, the shadow fading in dB scale changes according to a Gaussian auto-regressive (AR) process of order 1. The correlation distance of the shadow fading is 5, 50, and 250 meters in urban micro, urban macro, and suburban macro, respectively. The standard deviation of the shadow fading is 4 dB in LOS cases, and 10 dB in NLOS cases in all environments.

For recursive calls of the SCM function, it is possible to give initial shadow fading value for each link in the optional fourth input argument of the `scm.m` function. The name of the field is `sf_init` and it should be a vector with K elements, where K is the number of links to be simulated. For example, for two links, set `init_values.sf = [1, 4]` to set initial shadow fading values to 0 and 6 dBs. The final values of the shadow fading are output in the third output argument of the `scm.m` function.

The time-variant shadow fading feature can be switched on by setting `SCMPAR.DriftShadowFading = 'yes'`.

2.5 Time-varying angles and delays

The exact solution of the time-varying AoAs and delays from [SCME] is implemented. This feature can be switched on by setting `SCMPAR.DriftDelaysAngles = 'yes'`.

For all the subpaths, AoAs and distances are calculated for every channel snapshot. Delays of all subpaths within one midpath are set to the same value in order to preserve the concept of midpaths. This is a slight simplification compared to [SCME] which will be removed in later versions of the code.

`full_output0.delays` now also includes a time dimension, it is now a 3-dimensional matrix.

Note: delays values can be negative. If some delay increments are negative, then negative delays are possible to occur.

2.6 Reduced-variability TDL model parameters

An option to use tabulated delays and/or directions is included in SCME. This might be useful for example in some BER simulations. The fixed delays were selected to keep frequency correlation tolerable and to maintain specified RMS delay spread. The individual angle and delay values for different environments are given in [SCME].

Fixed delays can be switched on by setting `SCMPAR.FixedPdpUsed = 'yes'`. Fixed angles of departure and angles of arrival can be switched on by setting `SCMPAR.FixedAnglesUsed = 'yes'`. Note that random pairing of subpaths is *not* used when AoAs and AoDs are fixed. In other words, the angle of *m*th AoD subpath is coupled with the *m*th AoA subpath (for each path) [3GPP, Table 5.2].

3. Licensing and how to cite the work

The software is licensed under the GNU General Public License [GPL]. Basically, you can use the software for any purpose, provided that any programs or modifications you make and distribute are also licensed under the GNU GPL. See the license.txt file included in the distribution package.

If you use this channel model software, or any modified version, in scientific work you can cite this report as follows (IEEE style):

> D. S. Baum, J. Salo, M. Milojevic, P. Kyösti, and J. Hansen, "MATLAB implementation of the interim channel model for beyond-3G systems (SCME)," May 2005. [Online]. Available: http://www.tkk.fi/Units/Radio/scm/

4. References

[SCME] D. S. Baum, J. Salo, G. Del Galdo, M. Milojevic, P. Kyösti, and J. Hansen, "An interim channel model for beyond-3G systems," in *Proc. IEEE VTC'05*, Stockholm, Sweden, May 2005.

[WIN] WINNER project home page, https://www.ist-winner.org/

[SCM] "Spatial channel model for multiple input multiple output (MIMO) simulations", 3GPP TR 25.996 V6.1.0 (2003-09)

[SCMI] J. Salo, G. Del Galdo, J. Salmi, P. Kyösti, M. Milojevic, D. Laselva, and C. Schneider, "MATLAB implementation of the 3GPP spatial channel model (3GPP TR 25.996)," Jan 2005. [Online]. Available: http://www.tkk.fi/Units/Radio/scm/

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