IEEE P802.11
Wireless LANs

|  |
| --- |
| TGah Channel Model – Proposed Text |
| Date: 2011-07-19 |
| Author(s): |
| Name | Affiliation | Address | Phone | email |
| Ron Porat | Broadcom | 16340 West Bernardo Dr., San Diego, CA 92127 | 858-521-5409 | rporat@broadcom.com |
| SK Yong | Marvell | 5488 Marvell Lane, Santa Clara, 95054 | 408-222-8478 | skyong@marvell.com |
| Klaus Doppler | Nokia | 2054 University Ave, Berkeley, CA 94704 | 510-423-2458 | Klaus.Doppler@nokia.com |

# 3.0 Channel models

TGah channel model consists of outdoor and indoor channel models which are based on 3GPP/3GPP2 spatial channel model (SCM) and TGn (MIMO) channel models, respectively. Both models provide detailed modeling of the spatio-temporal characteristics of the multi-antenna propagation channel in ourdoor and indoor cases. Note that SCM and TGn models can also be configured for SISO simulation, and thus provide performance comparison between MIMO and SISO systems under the same channel model for both indoor and outdoor case, respectively.

An additional outdoor device to device model is added for simulations requiring explicit modelling of such cases.

Outdoor channels typically experience higher delay spread than is typically used for indoor models such as TGn. The actual delay spread depends on the environment and the elevation of the AP.The following table summarizes several values used in the SCM channel model [1] (left column), ITU-R guideline for 4G cellular networks evaluation [3] (midlle column), and TGn models (right column).

The 4G Urban Micro/Macro channels exhibit on average 129/365ns RMS delay spread, about half the corresponding SCM channel model. Urban Micro deployments are expected with antenna height at or about the height of the surrounding buildings. Urban/Suburban Macro deployments are expected with antenna height 10-15 meters above the surrounding buildings.

Abreviations used in the table –

* UMi – Urban Micro
* SMa – Suburban Macro
* UMa – Urban Macro
* InH – Indoor Hotspot
* RMa – Rural Macro
* LoS – Line of Sight
* NLoS – Non Line of Sight
* O-to-I – Outdoor to Indoor

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Scenario | RMS DS(ns) | Scenario | RMS DS(ns) | Scenario | RMS DS(ns) |
|  |  | 4G InH | LoS | 20 | TGn A | 0 |
|  |  | NLoS | 39 | TGn B | 15 |
|  |  | 4G UMi | LoS | 65 | TGn C | 30 |
| SCM UMi | 250 | NLoS | 129 | TGn D | 50 |
|  |  | O-to-I | 49 | TGn E | 100 |
|  |  | 4G SMa | LoS | 59 | TGn F | 150 |
| SCM SMa | 170 | NLoS | 75 |  |  |
|  |  | 4G UMa | LoS | 93 |  |  |
| SCM UMa | 650 | NLoS | 365 |  |  |
|  |  | 4G RMa | LoS | 32 |  |  |
|  |  | NLoS | 37 |  |  |

Table 1: Summary of RMS Delay Spread Values

**3.1 Spatial Channel Model (SCM)**

The Spatial Channel Model (SCM) is fully described in [1] and a freeware Matlab implementation can be downloaded from [2]. A Matlab wrapper file for generating 11ah channel profiles using this implementation is provided in the Appendix.

This channel model shall be used to evaluate 11ah outdoor link and system performance for SISO or MIMO links.

TGah use cases involve up to pedestrian mobility. However as reported in [4] and [5], reflections from cars cause higher Doppler and can be represented by assigning one of the six channel paths a higher Doppler value.

The following two simulation scenarios shall be used:

1. SCM with speed up to 3kmph for all paths
2. SCM with the fourth path assigned a speed of 60kmph and the rest of the paths assigned 0kmph.

**3.2 Outdoor Path Loss Models**

The path loss models for TGah outdoor scenarios are based on [6] and include two options:

1. Macro deployment - antenna height is assumed 15m above rooftop and the path loss in [dB] is given by the formula PL=8+37.6log10(d) where d is in meters and the RF carrier is assumed at 900MHz. For other frequencies a correction factor of 21log10(f/900MHz) should be added.
2. Pico/Hotzone deployment – antenna height is assumed at roof top level and the path loss is given by PL=23.3+36.7log10(d) with adjustment for other frequencies as above.

The above formulas represent the median path loss. Deviation around this median to account for shadowing should be modelled by adding a random Gaussian variable with zero mean and standard deviation of 8dB for Macro deployments and 10dB for Pico deployments.

In addition, penetration loss of 10 dB should be added when simulating indoor reception with outdoor access points.

**3.3 Outdoor Device to Device Path Loss Model**

The antenna height is assumed 1.5m and the path loss in [dB] is given by the formula
PL = -6.17 + 58.6\*log10(d) where d is in meters and the RF carrier is assumed at 900MHz.

The above formula represents the average path loss.  Deviation around this average to account for shadowing should be modelled by adding a random Gaussian variable with zero mean and a standard deviation of 7.5dB.

**3.4 Indoor MIMO Channel Models**

The proposed indoor channel model for TGah is based on the 802.11n channel models with relevant changes developed for TGac.These models have been widely used throughout the 802.11 standard development process. 802.11n model is described in [7] and the associated Matlab implementation is described in [8]. TGac channel model addendum is described in [9].

Relevant TGac channel model changes include chapters 4 and 5 in [9] for Multi-user MIMO and Doppler assumptions. TGah simulations for indoor scenarios should use these changes when simulating MU-MIMO or Doppler effects with appropriate scaling to TGah RF frequencies.

As described in [10], modifications to TGn path loss model are needed and this is described in section 3.4

**3.5 Indoor Path Loss Model**

TGah indoor path loss model can be modeledby directly scaling down the frequency operation of the TGn model which consists of the free space loss *LFS* (slope of 2) up to a breakpoint distance and slope of 3.5 after the breakpoint distance. This is given in equation (1) and (2), respectively.

$L\left(d\right)=L\_{FS}\left(d\right)=20log\_{10}\left(\frac{4πdf\_{c}}{C}\right) for d\leq d\_{BP}$ (1)

$L\left(d\right)=L\_{FS}\left(d\right)+ 3.5log\_{10}\left(\frac{d}{d\_{BP}}\right) for d>d\_{BP}$ (2)

where *d*, *f*c and *C* are the transmit-receive separation distance in *m*, center carrier frequency set to 900MHz and speed of light.

The path loss model parameters are summarized in Table 2. In the table, the standard deviations of log-normal shadow fading i.e. *X*σ[dB]=*N*(0, *σS*) is included, These values were lower than the corresponding values in TGn model by 1 dB as a result of lower operation frequency.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Model | *dBP* (m) | Slope before *dBP* | Slope after *dBP* | Shadow fading std. dev. (dB)before *dBP*(LOS) | Shadow fading std. dev. (dB)after *dBP*(NLOS) |
| A  | 5 | 2 | 3.5 | 2 | 3 |
| B | 5 | 2 | 3.5 | 2 | 3 |
| C | 5 | 2 | 3.5 | 2 | 4 |
| D | 10 | 2 | 3.5 | 2 | 4 |
| E | 20 | 2 | 3.5 | 2 | 5 |
| F | 30 | 2 | 3.5 | 2 | 5 |

Table 2: Path loss model parameters

The above model is valid for single floor scenario. In order to account for multiple-floor scenario, which is applicable to model A and B, floor attenuation factor (FAF) can be added as given in equation (3)

$L\left(d\right)=L\_{FS}\left(d\right)+ 35log\_{10}\left(\frac{d}{d\_{BP}}\right)+ \sum\_{q=1}^{Q}FAF\_{q} for d>d\_{BP}$ (3)

Where *q* is the floor index up to total number of floor, Q. FAF values for different number of floors is shown in Table 3 [11]

|  |  |  |
| --- | --- | --- |
| Total number of floors, Q | $\sum\_{q=1}^{Q}FAF\_{q}$ (dB) | σ (dB) |
| 1 | 12.9 | 7 |
| 2 | 18.7 | 2.8 |
| 3 | 24.4 | 1.7 |
| 4 | 27.7 | 1.5 |

Table 3: Average FAF and its associated standard deviation for the log normal shadowing effects for different number of floors. .57)dB)f floorserent number of floors is given by didicatons. tennas to 1 at both link. model channel models

Note that if (3) is used to characterize the path loss for multi-floor scenario, the associated standard deviations of log-normal shadow fading is shown in Table 3,

**References**

[1] 3GPP TR 25.996 - Technical Specification Group Radio Access Network; Spatial channel model for Multiple Input Multiple Output (MIMO) simulations, Section 5

[2] Link to Matlab implementation of [1]

<http://radio.tkk.fi/en/research/rf_applications_in_mobile_communication/radio_channel/scm-05-07-2006.zip>

[3] Report ITU-R M.2135-1 (12/2009) Guidelines for evaluation of radio interface technologies for IMT Advanced

[4] 11-03-0940-04-000n-tgn-channel-models.doc – channel model F

[5] 15-09-0742-01-004g-fading-in-900mhz-smart-utility-radio-channels.pdf – Steve Shearer

[6] 3GPP TR 36.814 - Further advancements for E-UTRA physical layer aspects, Annex A.2- system simulation scenario

[7] V. Erceg and et. al., TGn Channel Models, IEEE P802.11 Wireless LANs Std. IEEE 802.11-03/940r4, May 2004.

[8] L. Schumacher “WLAN MIMO Channel Matlab program,” download information: <http://www.info.fundp.ac.be/~lsc/Research/IEEE_80211_HTSG_CMSC/distribution_terms.html>

[9] TGac Channel Model Addendum - IEEE 802.11-09/308r12

[10] SK Yong, R. Barnerjae and H. Y. Zhang, “TGah Channel Model – Indooor Channel Model,” IEEE 802.11-11/0724r0

[11] S. Y. Seidel and T. S. Rappaport, “914 MHz path loss prediction models for wireless communications in multifloored buildings,” IEEE Trans. Antennas Propagat., vol. 40, no.2, pp. 207-217, Feb. 1992.

**Appendix**

**Matlab Wrapper file for Generating 11ah Channel Profiles using 3GPP SCM**

[TBD]