IEEE P802.11
Wireless LANs

|  |
| --- |
| TGah Channel Model – Proposed Text |
| Date: 2011-06-20 |
| 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 |

# 3.0 Channel models

TGah channel model consists of outdoor and indoor channel models which are based on 3GPP/3GPP2 (spatial channel model) 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.

**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].

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

TGah use cases involve up to pedestrian mobility. However as reported in [3] and [4], reflections from cars cause higher Doppler and can be represented by assigning one of the six channel taps a higher Doppler.

The following two simulation scenarios shall be used:

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

**Example Usage of SCM**

1. Download Matlab code from [2]. Main function is scm.m
2. Define several parameters
	1. scmpar.CenterFrequency=0.9e9;
	2. scmpar.Scenario='urban\_macro';
	3. scmpar.BsUrbanMacroAS='eight';
	4. scmpar.NumBsElements=4; (number of BS antennas)
	5. antpar.BsElementPosition=0.5; (antenna spacing)
	6. scmpar.NumMsElements=1;
	7. linkpar.MsVelocity=1kmph
	8. Call main function [H delays out]=scm(scmpar,linkpar,antpar); H is a time domain MIMO channel between all Tx and Rx antennas
3. Calculate frequency response

**3.2 Outdoor Path Loss Models**

The path loss models for TGah outdoor scenarios are based on [5] 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 average path loss. Deviation around this average 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 10dB should be added when simulating indoor reception with outdoor access points.

**3.3 Indoor MIMO Channel Models**

The proposed indoor channel model for TGah is based on the 802.11n channel models, which have been widely used in the 802.11 Standard development. 802.11n model is described in [6] and the associated Matlab implementation is described in [7].

As described in [8], modifications to TGn path loss model are needed and this is described in section 3.4

**3.4 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 1. 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 1: 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)

$L\left(d\right)=L\_{FS}\left(d\right)+ 3.5log\_{10}\left(\frac{d}{d\_{BP}}\right)+ \sum\_{q=1}^{Q}FAF\_{q}+ X\_{σ} for d>d\_{BP}$ (3)

FAF values for different number of floors is shown in Table 2 [9]

|  |  |  |
| --- | --- | --- |
| Number of floors | FAF (dB) | σ (dB) |
| 1 | 12.9 | 7 |
| 2 | 18.7 | 2.8 |
| 3 | 24.4 | 1.7 |
| 4 | 27.7 | 1.5 |

Table 2: Average FAF and its associated standard deviation for the log normal shadoqing 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 2,

**References**

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

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

[4] 15-09-0742-01-004g-fading-in-900mhz-smart-utility-radio-channels.pdf – Steve Shearer

[5] 3GPP TR 36.814 - Further advancements for E-UTRA physical layer aspects, Annex A.2- system simulation scenario

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

[7] L. Schumacher “WLAN MIMO Channel Matlab program,” download information:

<http://www.info.fundp.ac.be/~lsc/Research/IEEE_80211_HTSG_CMSC/distribution_terms.html>

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

[9] 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.