Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: [Overview of IEEE 802.16m channel models]
Date Submitted: [9 January 2013]
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Re: [In Response to Technical Guidance Document contributions for overview of 2.5GHz licensed band channel models]

Abstract: [Channel models for IEEE 802.16m]

Purpose: [For overview of reference channel models for proposals evaluation to TG8]

Overview of IEEE 802.16m EMD channel models

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Introduction

Introduction

- Purpose
  - To provide sufficient details for evaluating the system proposals to IEEE 802.16m
  - Targeting the IMT-Advanced standard
  - Provide MIMO channel models as key enabling technology for 802.16m and IMT-Advanced
  - Suggested:
    - 1) Mandatory & optional system level channel models
    - 2) Mandatory & optional link level channel models

Introduction

- Test scenarios

Scenario/Parameters	Baseline configuration TDD and FDD	NGMN configuration TDD and FDD	Urban Macrocell TDD and FDD
Requirement	**Mandatory**	**Optional**	**Optional**
Site-to-site distance	1.5km	0.5km	1km
Carrier frequency	2.5GHz	2.5GHz	2.5GHz
Operating bandwidth	10MHz for TDD / 10MHz per UL and DL for FDD	10MHz for TDD / 10MHz per UL and DL for FDD	10MHz for TDD / 10MHz per UL and DL for FDD
BS height	32m	32m	32m
BS Tx Power per sector	46 dBm (4 0W)	46 dBm (40 W)	46 dBm (40 W)
MS Tx Power	23 dBm (200 mW)	23 dBm (200 mW)	23 dBm (200 mW)
MS height	1.5m	1.5m	1.5m
Penetration loss	10 dB	20 dB	10 dB
Path loss model	130.19+37.6*log10(R) (R in km)	130.19+37.6*log10(R) (R in km)	35.2+35*log10(d)+26* log10(f/2), (d in meters)
Lognormal shadowing standard deviation	8dB	8dB	8dB

Introduction

- Test scenarios

Scenario/Parameters	Baseline configuration TDD and FDD	NGMN configuration TDD and FDD	Urban Macrocell TDD and FDD
Correlation distance for shadowing	50m	50m	50m
Mobility	0-120 km/hr	0-120 km/hr	0-120 km/hr
Channel mix	ITU Pedestrian B 3 km/hr – 60% ITU Vehicular A 30 km/hr – 30% ITU Vehicular A 120 km/hr – 10%	Low mobility: 3 km/hr UL: typical urban, DL: SCM-C Mixed mobility: ITU Pedestrian B 3 km/hr – 60% ITU Vehicular A 30 km/hr – 30% ITU Vehicular A 120 km/hr – 10%	3 km/hr – 60% 30 km/hr – 30% 120 km/hr – 10%
Spatial channel model	ITU with spatial correlation	Low mobility: 3 km/hr SCM Mixed mobility: ITU with spatial correlation	10MHz for TDD / 10MHz per UL and DL for FDD
Error Vector Magnitude (EVM)	30 dB	N/A	30 dB

Introduction

- Highlights in system-level channel modeling
  - Stochastic models
  - Spatial channel modeling
  - Mix of different speeds and channel scenarios
  - Pass loss, shadowing, cell radius, BS transmission power, antenna pattern, height, MS transmission power, height, gain factor, and etc. are included

Introduction

- Highlights in link-level channel modeling
  - Stochastic models
  - Incorporated double-directional (reciprocal) impulse response
    - Angle of departure (AoD)
    - Angle of arrival (AoA)
    - Spatial correlation matrix (per tap)
    - Consideration of polarization
  - Incorporated MIMO matrix channel response
    - Antenna patters at transmitter and receiver
    - Antenna pattern for horizontal and vertical polarization
    - Considered elevation and azimuth
    - Spatial correlation matrix (per tap)
  - Generation of spatial channels (including MIMO channel)
    - 1) Correlation based method
    - 2) Ray based method

System level channel model

Pass loss models (mandatory)

- 1) Carrier frequency
  - 2.5GHz
- 2) Uniform height of buildings
  - R in km, f in MHz, h_{BS} in meters

$$PL(dB) = 40(1-4\cdot 10^{-3} h_{BS})\cdot \log_{10}(R) - 18\cdot \log_{10}(h_{BS}) + 21\cdot \log_{10}(f) + 80$$

- 3) 15m above rooftop baseline configuration path loss
  - R in km $PL(dB) = 130.19 + 37.6\cdot \log_{10}(R)$
- 4) lognormal shadowing standard deviation
  - 8dB

Pass loss models (optional)

- 1) Urban Macrocell (f[GHz]: 2 < f < 6)
  - BS height: 32m, MS height: 1.5m

$$PL(dB) = 35.2 + 35 \cdot \log_{10}(d) + 26 \cdot \log_{10}(f/2)$$

- 2) Suburban Macrocell
  - BS height: 32m, MS height: 1.5m

$$PL(dB) = PL_{urban\_macro} - 2[1.5528 + \log_{10}(f)]^2 - 5.4$$

- 3) Urban Microcell
  - BS: height: 12.5m, MS height: 1.5m
  - Refer to [1]

Pass loss models (optional)

- 5) Indoor Small Office
  - Refer to [2]

- 6) Indoor Hot Spot
  - LOS (20m < d < 60m, $h_{BS} = h_{MS} = 1\sim2.5$m)

$$PL(dB) = 35.2 + 35 \cdot \log_{10}(d) + 26 \cdot \log_{10}(f/5.0)$$

  - NLOS (20m < d < 80m, $h_{BS} = h_{MS} = 1\sim2.5$m)

$$PL(dB) = 25.5 + 43.3 \cdot \log_{10}(d) + 20 \cdot \log_{10}(f/5.0)$$

Pass loss models (optional)

- 7) Outdoor to Indoor
  - Refer to [2]

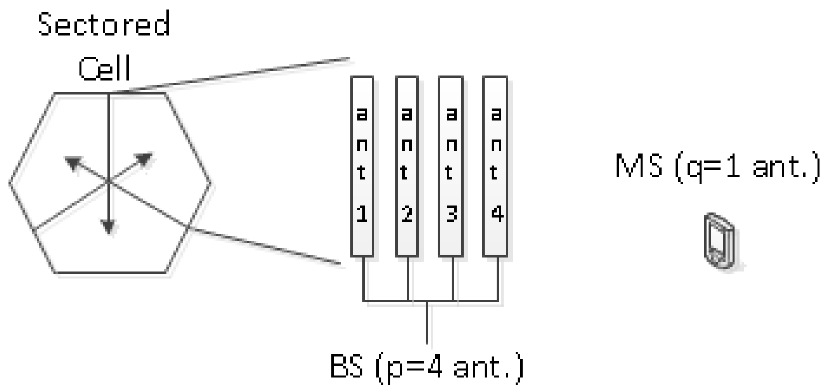
$$PL(dB) = PL + 14 + 15(1 - \cos(\theta))2 + 0.5 \cdot d_{in}$$

- 8) Open Rural Macrocell
  - Refer to [2]

Link level channel model

Baseline test scenario (Mandatory)

- Case 1) Uncorrelated antennas at both BS and MS
- Case 2) Uncorrelated antennas at MS, correlated antennas at BS
  - Spatial correlation calculation
    - Derived from 20 sub-paths resulting Laplacian PDF
    - Antenna spatial correlation coefficients



PDP for baseline test scenarios (Mandatory)

- Modified ITU baseline channel models
  - ITU pedestrian B (6-taps => 24-taps)
  - ITU vehicular A (6-taps => 24-taps)
- Realization of a time-varying spatial channel
  - Correlation based method: antenna correlation for each tap is computed first according the per-tap mean AoA/AoD, per-tap power angular profile, and antenna configuration parameters.
- Considered for a 10MHz system bandwidth
  - TDD: 10MHz
  - FDD: 10MHz for both UL and DL

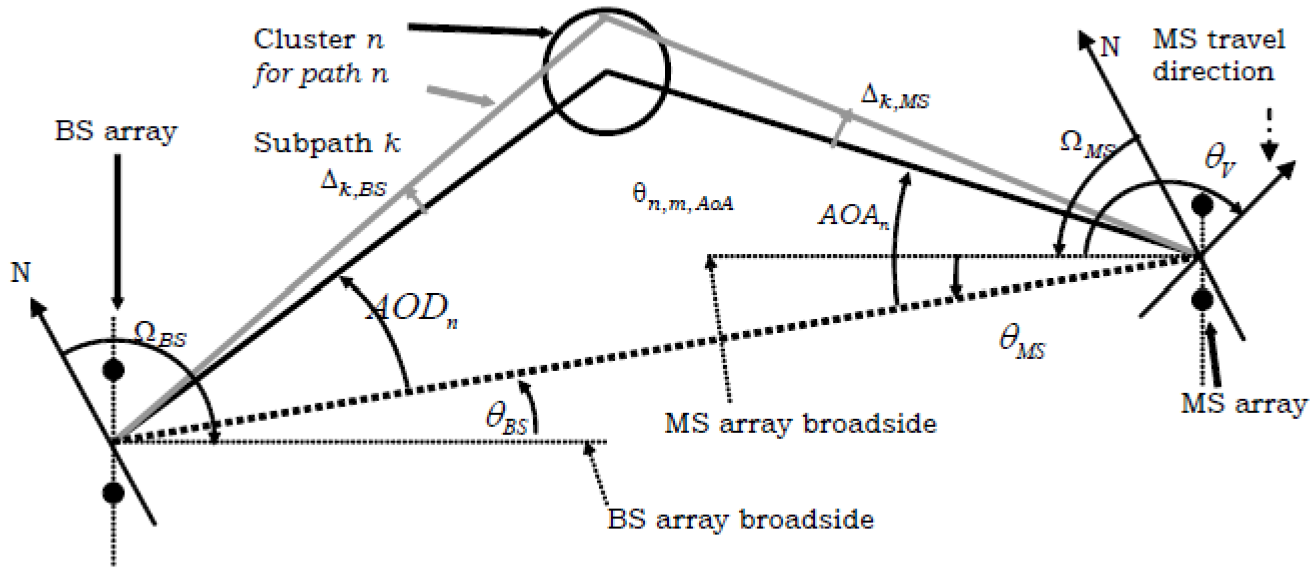
PDP for baseline test scenarios (Mandatory)

- Modified ITU baseline channel models

Path Index	Modified Pedestrian B		Modified Vehicular A	
	Power (dB)	Delay (ns)	Power (dB)	Delay (ns)
1	-1.175	0	-3.1031	0
2	0	40	-0.4166	50
3	-0.1729	70	0	90
4	-0.2113	120	-1.0065	130
5	-0.2661	210	-1.4083	270
6	-0.3963	250	-1.4436	300
7	-4.32	290	-1.5443	390
8	-1.1608	350	-4.0437	420
9	-10.4232	780	-16.6369	670
10	-5.7198	830	-14.3955	750
11	-3.4798	880	-4.9259	770
12	-4.1745	920	-16.516	800
13	-10.1101	1200	-9.2222	1040
14	-5.646	1250	-11.9058	1060
15	-10.0817	1310	-10.1378	1070
16	-9.4109	1350	-14.1861	1190
17	-13.9434	2290	-16.9901	1670
18	-9.1845	2350	-13.2515	1710
19	-5.5766	2380	-14.8881	1820
20	-7.6455	2400	-30.348	1840
21	-38.1923	3700	-19.5257	2480
22	-22.3097	3730	-19.0286	2500
23	-26.0472	3760	-38.1504	2540
24	-21.6155	3870	-20.7436	2620

PDP for baseline test scenarios (Mandatory)

- Angle parameters



PDP for baseline test scenarios (Mandatory)

- Spatial correlation matrix calculation (correlation based method)
  - Derived from 20 sub-paths resulting Laplacian PDF
  - Angular spread of 3 degrees $AS_{BS,path} = 3^o$
  - Inter-element spacing of 4 wavelengths $\lambda = 4$
  - Angular offsets of the k-th (k=1,2,..20) sub-path are determined by

$$\psi_{k,BS} = \Delta_k \cdot AS_{BS,path}$$

$$\psi_{k,MS} = \Delta_k \cdot AS_{MS,path}$$

Sub-path number k	Δ_k
1,2	± 0.0447
3,4	± 0.1413
5,6	± 0.2492
7,8	± 0.3715
9,10	± 0.5129
11,12	± 0.6797
13,14	± 0.8844
15,16	± 1.1481
17,18	± 1.5195
19,20	± 2.1551

PDP for baseline test scenarios (Mandatory)

- Spatial correlation matrix calculation
  - **Step1)** Derivation of antenna spatial correlation at the BS and MS between the *p*-th and *q*-th antenna as:

$$r_{n,BS}(p,q)=\frac{1}{20}\sum_{k=1}^{20}\exp\left\{j\frac{2\pi d_{BS}}{\lambda}(p-q)\sin(AoD_n+\psi_{k,BS}+\theta_{BS})\right\}$$

$$r_{n,MS}(p,q)=\frac{1}{20}\sum_{k=1}^{20}\exp\left\{j\frac{2\pi d_{MS}}{\lambda}(p-q)\sin(AoA_n+\psi_{k,MS}+\theta_{MS})\right\}$$

  - **Step2)** Denoting the spatial correlation matrix at BS and MS as $\mathbf{R}_{BS,n}$ and $\mathbf{R}_{MS,n}$, the per-tap spatial correlation is determined as

$$\mathbf{R}_n=\mathbf{R}_{BS,n}\otimes\Gamma\otimes\mathbf{R}_{MS,n}$$

  - Γ is a 2x2 matrix if cross-polarized antennas are used at BS and MS

PDP for baseline test scenarios (Mandatory)

- Spatial correlation matrix calculation
  - **Step3)** Generate NxM i.i.d. channels that satisfies Jake's Doppler spectrum where N is the number of RX antennas and M is the number of TX antennas
  - **Step4)** compute the correlated channel at each tap as

$$\mathbf{H}_n = unvec\left\{ R_n^{1/2} vec\left(H_{iid} \right) \right\}$$

Cluster-Delay-Line models (optional)

- 1) Urban Macrocell
- 2) Suburban Macrocell
- 3) Urban Microcell
- 4) Suburban Microcell
- 5) Indoor Small Office
- 6) Indoor Hot Spot
- 7) Outdoor to Indoor
- 8) Open Rural Macrocell

Cluster-Delay-Line models

- CDL concept
  - Referred as conventional tap delayed line models of power delay profile with the addition of
    - 1) Per-tap AoA, AoD information
    - 2) Per-tap angular spread (power angular profile) information
  - A group of multi-path (taps) components form a cluster
  - Each cluster (tap) have 20 equal-power rays with fixed offset angles
    - Thus, the ray power is 1/20 of the mean tap power (i.e. -13dB)
  - A cluster can be divided into three sub-clusters

Cluster-Delay-Line models

- Urban Macrocell
  - XPR = 5dB

Cluster #	Delay [ns]			Power [dB]			AoD [º]	AoA [º]	Ray power [dB]	Cluster AS_{BS} = 2º	Cluster AS_{MS} = 15º
1	0			-6.4			11	61	-19.5		
2	60			-3.4			-8	44	-16.4		
3	75			-2.0			-6	-34	-15.0		
4	145	150	155	-3.0	-5.2	-7.0	0	0	-13.0		
5	150			-1.9			6	33	-14.9		
6	190			-3.4			8	-44	-16.4		
7	220	225	230	-3.4	-5.6	-7.4	-12	-67	-13.4		
8	335			-4.6			-9	52	-17.7		
9	370			-7.8			-12	-67	-20.8		
10	430			-7.8			-12	-67	-20.8		
11	510			-9.3			13	-73	-22.3		
12	685			-12.0			15	-83	-25.0		
13	725			-8.5			-12	-70	-21.5		

Cluster-Delay-Line models

- Urban Macrocell
  - XPR = 5dB

14	735	-13.2	-15	87	-26.2		
15	800	-11.2	-14	80	-24.2		
16	960	-20.8	19	109	-33.8		
17	1020	-14.5	-16	91	-27.5		
18	1100	-11.7	15	-82	-24.7		
19	1210	-17.2	18	99	-30.2		
20	1845	-16.7	17	98	-29.7		

Cluster-Delay-Line models

- Bad Urban Macrocell
  - XPR = 5dB

Cluster #	Delay [ns]	Power [dB]	AoD [º]	AoA [º]	Ray power [dB]		
1	0	-4.7	-10	61	-17.7	Cluster AS_{BS} = 2º	Cluster AS_{MS} = 15º
2	0 5 10	-3 -5.2 -7	0	0	-13		
3	10	-7.2	12	-75	-20.2		
4	10	-6.3	-11	-70	-19.3		
5	30 35 40	-4.8 -7 -8.8	-12	76	-14.8		
6	50	-3.7	-9	53	-16.7		
7	80	-7.4	-12	76	-20.4		
8	110	-7.2	12	-75	-20.2		
9	155	-9.6	14	-87	-22.7		
10	165	-5.2	-10	64	-18.3		
11	165	-6.3	11	70	-19.3		
12	250	-8.9	14	83	-21.9		
13	280	-8.5	13	-81	-21.5		
14	440	-8.4	13	-81	-21.4		
15	490	-8.5	-13	81	-21.5		
16	525	-5	10	62	-18		
17	665	-10.9	15	92	-23.9		
18	685	-10.9	15	92	-24		
19	4800	-9.7	-135	25	-22.7		
20	7100	-13	80	40	-26		

Cluster-Delay-Line models

- Suburban Macrocell
  - XPR = 5.5dB

Cluster #	Delay [ns]			Power [dB]			AoD [º]	AoA [º]	Ray power [dB]	Cluster AS_{BS} = 2º	Cluster AS_{MS} = 10º
1	0	5	10	-3.0	-5.2	-7.0	0	0	-13.0		
2	25			-7.5			13	-71	-20.5		
3	35			-10.5			-15	-84	-23.5		
4	35			-3.2			-8	46	-16.2		
5	45	50	55	-6.1	-8.3	-10.1	12	-66	-16.1		
6	65			-14.0			-17	-97	-27.0		
7	65			-6.4			12	-66	-19.4		
8	75			-3.1			-8	-46	-16.1		
9	145			-4.6			-10	-56	-17.6		
10	160			-8.0			-13	73	-21.0		
11	195			-7.2			12	70	-20.2		
12	200			-3.1			8	-46	-16.1		
13	205			-9.5			14	-80	-22.5		
14	770			-22.4			22	123	-35.4		

Cluster-Delay-Line models

- Urban Microcell
  - LOS (Ricean K-factor is 3.3dB)
  - XPR = 9.5dB

Cluster #	Delay [ns]			Power [dB]			AoD [º]	AoA [º]	Ray power [dB]		Cluster ASD = 3º	Cluster AS_{MS} = 18º
1	0			0.0			0	0	-0.31*	-24.7**		
2	30	35	40	-10.5	-12.7	-14.5	5	45	-20.5			
3	55			-14.8			8	63	-27.8			
4	60	65	70	-13.6	-15.8	-17.6	8	-69	-23.6			
5	105			-13.9			7	61	-26.9			
6	115			-17.8			8	-69	-30.8			
7	250			-19.6			-9	-73	-32.6			
8	460			-31.4			11	92	-44.4			

Cluster-Delay-Line models

- Urban Microcell
  - NLOS
  - XPR = 7.5dB

<table>
<tr><th>Cluster #</th><th colspan="3">Delay [ns]</th><th colspan="3">Power [dB]</th><th>AoD [º]</th><th>AoA [º]</th><th>Ray power [dB]</th><th></th><th></th></tr>
<tr><td>1</td><td colspan="3">0</td><td colspan="3">-1.0</td><td>8</td><td>-20</td><td>-14.0</td><td rowspan="16">Cluster AS_{BS} = 10º</td><td rowspan="16">Cluster AS_{MS} = 22º</td></tr>
<tr><td>2</td><td>90</td><td>95</td><td>100</td><td>-3.0</td><td>-5.2</td><td>-7.0</td><td>0</td><td>0</td><td>-13.0</td></tr>
<tr><td>3</td><td>100</td><td>105</td><td>110</td><td>-3.9</td><td>-6.1</td><td>-7.9</td><td>-24</td><td>57</td><td>-13.9</td></tr>
<tr><td>4</td><td colspan="3">115</td><td colspan="3">-8.1</td><td>-24</td><td>-55</td><td>-21.1</td></tr>
<tr><td>5</td><td colspan="3">230</td><td colspan="3">-8.6</td><td>-24</td><td>57</td><td>-21.6</td></tr>
<tr><td>6</td><td colspan="3">240</td><td colspan="3">-11.7</td><td>29</td><td>67</td><td>-24.7</td></tr>
<tr><td>7</td><td colspan="3">245</td><td colspan="3">-12.0</td><td>29</td><td>-68</td><td>-25.0</td></tr>
<tr><td>8</td><td colspan="3">285</td><td colspan="3">-12.9</td><td>30</td><td>70</td><td>-25.9</td></tr>
<tr><td>9</td><td colspan="3">390</td><td colspan="3">-19.6</td><td>-37</td><td>-86</td><td>-32.6</td></tr>
<tr><td>10</td><td colspan="3">430</td><td colspan="3">-23.9</td><td>41</td><td>-95</td><td>-36.9</td></tr>
<tr><td>11</td><td colspan="3">460</td><td colspan="3">-22.1</td><td>-39</td><td>-92</td><td>-35.1</td></tr>
<tr><td>12</td><td colspan="3">505</td><td colspan="3">-25.6</td><td>-42</td><td>-99</td><td>-38.6</td></tr>
<tr><td>13</td><td colspan="3">515</td><td colspan="3">-23.3</td><td>-40</td><td>94</td><td>-36.4</td></tr>
<tr><td>14</td><td colspan="3">595</td><td colspan="3">-32.2</td><td>47</td><td>111</td><td>-45.2</td></tr>
<tr><td>15</td><td colspan="3">600</td><td colspan="3">-31.7</td><td>47</td><td>110</td><td>-44.7</td></tr>
<tr><td>16</td><td colspan="3">615</td><td colspan="3">-29.9</td><td>46</td><td>-107</td><td>-42.9</td></tr>
</table>

Cluster-Delay-Line models

- Bad Urban Microcell
  - NLOS
  - XPR = 7.5dB

Cluster #	Delay [ns]			Power [dB]			AoD [º]	AoA [º]	Ray power [dB]		
1	0	5	10	-3.0	-5.2	-7.0	0	0	-13.0	Cluster AS_{BS} = 3º	Cluster AS_{MS} = 5º
2	25	30	35	-3.4	-5.6	-7.3	-14	31	-13.4		
3	25			-1.7			-13	30	-14.7		
4	35			-1.9			-14	31	-14.9		
5	45			-2.2			15	-34	-15.2		
6	70			-5.0			22	51	-18.0		
7	70			-3.6			19	44	-16.6		
8	90			-3.8			-19	-45	-16.8		
9	155			-6.4			-25	-58	-19.4		
10	170			-2.7			-17	-38	-15.7		
11	180			-7.5			-27	-63	-20.5		
12	395			-16.5			-41	93	-29.5		
13	1600			-5.7			-110	15	-18.7		
14	2800			-7.7			75	-25	-20.7		

Cluster-Delay-Line models

- Indoor Small Office
  - NLOS
  - XPR = 10dB

Cluster #	Delay [ns]			Power [dB]			AoD [°]	AoA [°]	Ray power [dB]		
1	0	5	10	-3.0	-5.2	-7.0	0	0	-13.0	Cluster AS_{BS} = 5°	Cluster AS_{MS} = 5°
2	5			-4.0			59	-55	-17.0		
3	20			-4.7			-64	-59	-17.7		
4	25			-9.0			89	-82	-22.0		
5	30			-8.0			83	-77	-21.0		
6	30	35	40	-4.0	-6.2	-8.0	-67	62	-14.0		
7	35			-1.1			32	29	-14.2		
8	45			-5.2			-67	62	-18.2		
9	55			-9.5			-91	-84	-22.5		
10	65			-7.9			-83	77	-20.9		
11	75			-6.8			-77	-71	-19.8		
12	90			-14.8			-113	105	-27.8		
13	110			-12.8			-106	98	-25.8		
14	140			-14.1			111	-103	-27.2		
15	210			-26.7			-152	141	-39.7		
16	250			-32.5			-168	-156	-45.5		

Cluster-Delay-Line models

- Indoor Hotspot
  - LOS
  - XPR = 11dB

<table>
<tr><th>Cluster #</th><th>Delay [ns]</th><th>Power [dB]</th><th>AoD [º]</th><th>AoA [º]</th><th colspan="2">Ray power [dB]</th><th rowspan="16">Cluster AS_{BS} = 5º</th><th rowspan="16">Cluster AS_{MS} = 8º</th></tr>
<tr><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>-0.1*</td><td>-28.4**</td></tr>
<tr><td>2</td><td>5</td><td>-3.4</td><td>7</td><td>-2</td><td>-3.7*</td><td>-27.1**</td></tr>
<tr><td>3</td><td>10</td><td>-9.2</td><td>0</td><td>-12</td><td colspan="2">-22.2</td></tr>
<tr><td>4</td><td>20</td><td>-18.9</td><td>7</td><td>13</td><td colspan="2">-31.9</td></tr>
<tr><td>5</td><td>30</td><td>-17.1</td><td>11</td><td>16</td><td colspan="2">-30.1</td></tr>
<tr><td>6</td><td>40</td><td>-16.3</td><td>-7</td><td>-34</td><td colspan="2">-29.3</td></tr>
<tr><td>7</td><td>50</td><td>-13.7</td><td>-60</td><td>-12</td><td colspan="2">-26.7</td></tr>
<tr><td>8</td><td>60</td><td>-16.3</td><td>-43</td><td>-17</td><td colspan="2">-29.3</td></tr>
<tr><td>9</td><td>70</td><td>-16.8</td><td>11</td><td>-59</td><td colspan="2">-29.8</td></tr>
<tr><td>10</td><td>80</td><td>-17.9</td><td>8</td><td>-78</td><td colspan="2">-30.9</td></tr>
<tr><td>11</td><td>90</td><td>-15.9</td><td>14</td><td>-65</td><td colspan="2">-28.9</td></tr>
<tr><td>12</td><td>100</td><td>-17.4</td><td>-1</td><td>-56</td><td colspan="2">-30.4</td></tr>
<tr><td>13</td><td>110</td><td>-25.8</td><td>-11</td><td>-57</td><td colspan="2">-38.8</td></tr>
<tr><td>14</td><td>120</td><td>-31.0</td><td>-129</td><td>-22</td><td colspan="2">-44.0</td></tr>
<tr><td>15</td><td>130</td><td>-33.4</td><td>-123</td><td>-12</td><td colspan="2">-46.4</td></tr>
</table>

Cluster-Delay-Line models

- Indoor Hotspot
  - NLOS, XPR = 11dB

Cluster #	Delay [ns]	Power [dB]	AoD [º]	AoA [º]	Ray power [dB]		
1	0	-6.9	2	2	-19.9	Cluster AS_{BS} = 5º	Cluster AS_{MS} = 11º
2	5	0	-2	9	-13.0		
3	10	-0.7	-7	14	-13.7		
4	15	-1.0	-3	-7	-14.0		
5	20	-1.4	-1	-6	-14.4		
6	25	-3.8	-5	-18	-16.8		
7	30	-2.6	0	-3	-15.6		
8	35	-0.2	-6	-3	-13.2		
9	45	-3.6	-9	14	-16.6		
10	55	-5.7	1	44	-18.7		
11	65	-11.6	4	13	-24.6		
12	75	-8.9	-5	65	-21.9		
13	95	-7.3	-11	46	-20.3		
14	115	-11.2	-4	35	-24.2		
15	135	-13.5	-3	48	-26.5		
16	155	-13.4	-7	41	-26.4		
17	175	-12.2	8	7	-25.2		
18	195	-14.7	4	69	-27.7		
19	215	-15.8	-11	133	-28.8		

Cluster-Delay-Line models

- Rural Macrocell
  - LOS, XPR = 7dB
  - Ricean K-factor is 13.7dB

Cluster #	Delay [ns]			Power [dB]			AoD [°]	AoA [°]	Ray power [dB]			
1	0			0.0			0	0	-0.02*	-35.9**	Cluster AS_{BS} = 2°	Cluster AS_{MS} = 3°
2	40			-22.3			-95	189	-35.3			
3	40			-25.6			102	203	-38.6			
4	40	45	50	-23.1	-25.3	-27.1	-90	-179	-33.1			
5	40	45	50	-23.7	-25.9	-27.7	104	-208	-33.7			
6	60			-27.4			-105	210	-40.4			
7	115			-27.0			104	-208	-40.0			
8	135			-25.2			-101	-201	-38.2			
9	175			-30.1			110	-219	-43.1			
10	195			-32.5			114	228	-45.5			
11	215			-31.7			-113	-225	-44.7			
12	235			-33.9			-117	-233	-46.9			
13	235			-31.0			-112	223	-44.0			

Cluster-Delay-Line models

- Rural Macrocell
  - NLOS, XPR = 7dB

Cluster #	Delay [ns]			Power [dB]			AoD [º]	AoA [º]	Ray power [dB]		
1	0	5	10	-3.0	-5.2	-7.0	0	0	-13.0	Cluster AS_{BS} = 2º	Cluster AS_{MS} = 3º
2	0			-1.8			-8	28	-14.8		
3	5			-3.3			-10	38	-16.3		
4	10	15	20	-4.8	-7.0	-8.8	15	-55	-14.8		
5	20			-5.3			13	48	-18.3		
6	25			-7.1			15	-55	-20.1		
7	55			-9.0			-17	62	-22.0		
8	100			-4.2			-12	42	-17.2		
9	170			-12.4			20	-73	-25.4		
10	420			-26.5			29	107	-39.5		

Considerations to general MS to MS environments

- Since LOS probability for low mounted transmitters will significantly increase the expected path loss for longer range peer-to-peer connections, we need some modifications to path-loss models shown in the EMD document.
- Such modifications to the path loss model in the EMD mandatory case could be described as:

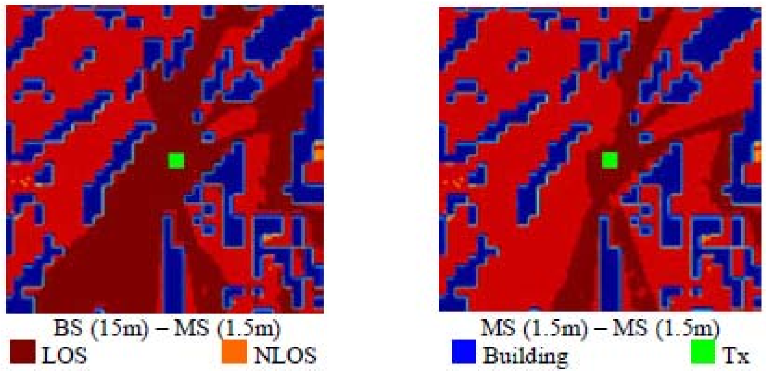
$$PL(dB) = \alpha \cdot 40(1 - 4 \cdot 10^{-3} h_{BS}) \cdot \log_{10}(R) - \beta \cdot 18 \cdot \log_{10}(h_{BS}) + 21 \cdot \log_{10}(f) + 80$$

$$R \leq R_{bp}, \quad \alpha_1$$

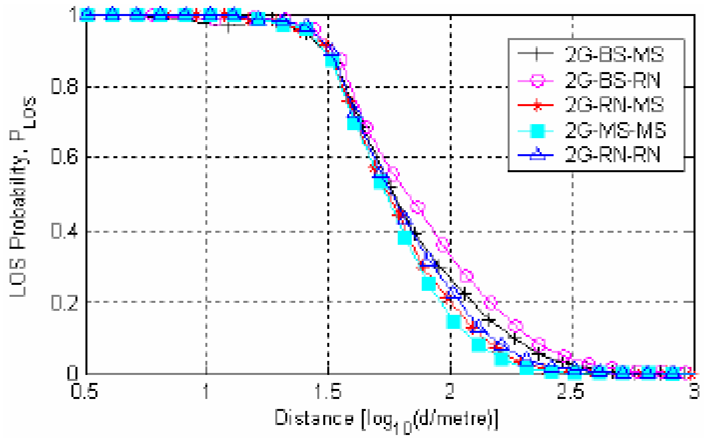
$$R > R_{bp}, \quad \alpha_2$$

Considerations to general MS to MS environments

- Same site with different Tx heights in an urban area

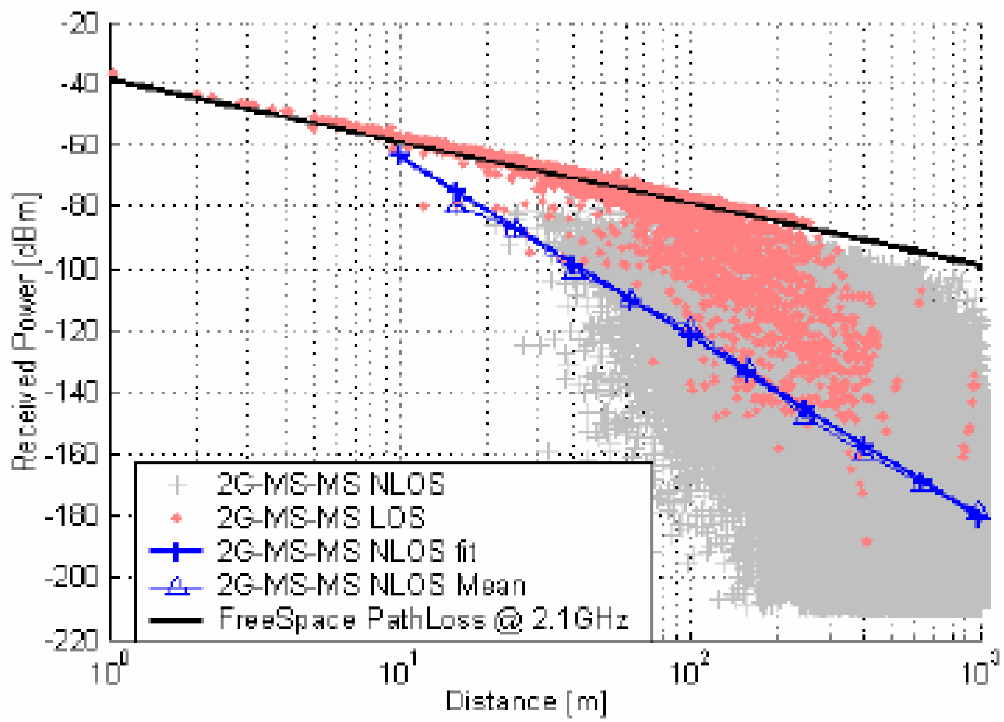


- LOS probability v.s. distance



Considerations to general MS to MS environments

- Statistical plot of the received power versus distance [3]



References

- [1] IEEE 802.16m-08/004r2
- [2] IST-WINNER II Deliverable D1.1.1 v1.0 "WINNER II Interim Channel Models", December 2006
- [3] Z. Wang, E. K. Tameh, and A. R. Nix, "Statistical peer-to-peer channel models for outdoor urban environments at 2GHz and 5GHz", VTC 2004 Fall, Los Angeles, CA

Thank You

Any Questions?