Project	IEEE 802.16 Broadband Wireless Access Working Group <**http://ieee802.org/16**>
Title	Comments on IEEE 802.16j Channel Models in IEEE802.16j-06/013
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Re:	Response to chair’s call for comments on IEEE 802.16j-06/013 “Multi-hop Relay System Evaluation Methodology (Channel Model and Performance Metric)”
Abstract	This contribution includes the comments on the path-loss models and shadow fading parameters in IEEE 802.16j-06/013
Purpose	Improve the path-loss models and shadow fading parameters in IEEE 802.16j-06/013
Notice	
Release	
Patent Policy and Procedures	

Comments on IEEE 802.16j Channel Models in IEEE 802.16j-06/013

Introduction

This contribution includes the comments and proposes the text for the path-loss models and shadowing fading parameters for IEEE 802.16j-06/013 “Multi-hop Relay System Evaluation Methodology (Channel Model and Performance Metric)” [1], which is shown as following sections.

The conventional IEEE 802.16 channel measurements [2] are performed for macro-cellular (large cell propagation environment) deployment with a tall BS (10-40meters) and 2-10 meters directional antennas at the receiver. However, the relay environment is most likely to deploy many RSs in micro-cellular systems such as BS only covers the metropolitan area (the coverage is only couple kilometers). Hence, the propagation environment of the conventional IEEE 802.16 channels may not reflect the reality of the MMR (multi-hop relay) systems for IEEE 802.16j. We, therefore, propose the WINNER path-loss model [3] again for IEEE 802.16j Multi-hop Relay project. Although it is measured in European cities, the realistic and simple channel models can provide enough information when people are ready to evaluate the performances of multi-hop relay systems for any metropolitan area.

In addition, we found the following problems with the current path-loss and shadowing models listed in IEEE802.16j-06/013:

1. The path-loss models proposed in IEEE 802.16j-06/013 is very much incomplete. For example, the models for Type D (RS to RS, LOS, ART to ART) and Type E (BS to RS, NLOS, ART to BRT) described in IEEE802.16j-06/013 share parameters with other types of deployment.
2. The standard deviations of log-normal shadow fading for different Type D/E/F/G/H which are missing in IEEE 802.16j-06/013.
3. LOS (Line-Of-sight) probability is missing in the conventional 802.16 model, and it is important to determine the propagation scenario for each radio link. We believe this probability should be specified based on realistic measurement results instead of randomly assigned value.

COMMENTS ON IEEE 802.16j-06/013 BASELINE DOCUMENT

1. Comments on "2.1.1 Path-loss Types" in IEEE 802.16j-06/013 baseline document

We would like to propose the following table to improve the existing one in IEEE802.16j-06/013 baseline document:

---Start of the Text---

Table 1 Summary Table of Path-loss Types for IEEE802.16j Relay System

Category	Description		Reference	Note
Type A	Hilly terrain with moderate-to-heavy tree densities (For large macro-cellular systems)		Section 2.1.2.1	IEEE 802.16 Type A model
Type B	Intermediate path-loss condition (For large macro-cellular systems)			IEEE 802.16 Type B model
Type C	Flat terrain with light tree densities (For large macro-cellular systems)			IEEE 802.16 Type C model
Type D	Both node-antennas above rooftop	LOS	Section 2.1.2.2	WINNER B5a or free-space model before the breakpoint
				Advanced LOS after the breakpoint
Type E	One node-antenna above rooftop and another below rooftop (For suburban macro-cell)	LOS	Section 2.1.2.3	WINNER C1 LOS
		NLOS		WINNER C1 NLOS
Type F	One node-antenna above rooftop and another below rooftop (For urban macro-cell)	NLOS	Section 2.1.2.4	WINNER C2
Type G	Both node-antennas below rooftop (For urban micro-cell)	LOS	Section 2.1.2.5	WINNER B1 LOS
		NLOS		WINNER B1 NLOS
Type H	Indoor office	LOS	Section 2.1.2.6	WINNER A1 LOS
		NLOS		WINNER A1 NLOS

Suburban macro-cell definition: The BS is located well above the rooftops to allow wide area coverage. Buildings are typically low residential detached houses with one or two floors, or blocks of flats with a few floors [3].

Urban macro-cell definition: The BS clearly above surrounding building height and MS is at street level. As for propagation conditions, NLOS probability is very high, since street level is often reached by a single diffraction over the rooftop. The building blocks can form either a regular Manhattan type of grid, or have more irregular locations. Typical building heights in urban environments are over four-stories [3].

Urban micro-cell definition: Both BS and MS antenna heights are below surrounding building and both are outdoors. The environment is defined for Manhattan like grid. The environment streets can be classified as a main street (i.e., where the BS is located), perpendicular streets and parallel streets. The scenario is defined for street distance from 20m to 400m.

Indoor office definition: This represents typical office environment, where the area per floor is 5000 square meters, average number of floor is 3 and room dimensions are 10m*10m*3m and the corridors have the dimensions 100m*5m*3m [3].

---End of the Text---

Note that the path-loss exponent and *S* coefficients of the advanced LOS model in [1] need to be further verified.

2. Comment on " 2.1.2.1 Type-A/B/C: (BS ↔ MS, BS ↔ MRS, BS ↔ NRS) " in IEEE 802.16j-06/013 document

These Type-A/B/C models are for large macro-cellular systems. Typically, the range of cell radius is from 1km to 10 km. The propagation environment taken into account is the terrains and large clusters. This is not fit into the typical small macro-cell or micro-cell systems which only cover the metropolitan city or urban area. The propagation environment considered in this area should include the buildings and small cluster. WINNER models are specifically developed for the micro-cell system with MIMO consideration which is closer to the IEEE802.16j MMR-BS and RS propagation environment.

3. Comment on "2.1.2.2 Type-D: BS↔RS, LOS (ART-to-ART)" in IEEE 802.16j-06/013 document

In the caption of Figure 2, BS-RS link only considers LOS because both transmit/receive antennas are above the rooftop and consider the over-rooftop propagation scenario. Therefore, the NLOS situation should be deleted in this section. The text of the 2.1.2.2 Type-D path-loss model in the IEEE 802.16j-06/013 baseline document is incorrect. Since we assume the two transmit/receive antennas are all above rooftop, these two antennas are always in the LOS situation. We may assume the pathloss in this model is close to the free space path-loss up to the breakpoint which may be a function of the transmission frequency, the antenna height, and the average rooftop height. This breakpoint assumption is applied from the first Fresnel zone clearance approach. Beyond the breakpoint, the path loss exponent increases due to the Fresnel zone effect and it is not because "the LOS probability will decrease with distance from the BS" as described in the original baseline text. The path-loss model used in the 2.1.2.2 Type-D is IEEE802.16 model which is for the hilly, medium, or flat terrain condition. It does not fit into the over-rooftop situation used in IEEE802.16j scenario.

We suggest using WINNER B5a or Free-space model before the breakpoint. After the breakpoint, we may use advanced LOS approach or others.. The detailed suggestions are as following:

--Start of the Text--

2.1.2.2 Type-D: LOS (ART-to-ART)

The following path-loss model is considered for Type-D LOS scenario before the breakpoint:

$$Pathloss(d) = 36.5 + 20 \cdot \log_{10}(f_c/2.5) + 23.5 \cdot \log_{10}(d) \text{ dB}$$

where d is the distance in meter and 30m < d < d_B. f_c is the carrier frequency in GHz. We may also use Free-space model to approach it.

The breakpoint, d_B, is define as

$$d_B = 4\frac{(h_t - h_o)(h_r - h_o)}{\lambda}$$

Where $h_{t,} h_r$ are transmit and receive antenna heights from the ground level, h_o is the average building height between transmit and receive antennas, and λ is the carrier wavelength.

--End of the Text--

The path-loss model after the breakpoint may use the Advanced LOS model in [1].

4. Comment on "2.1.2.3 Type-D: RS↔RS, LOS (ART-to-ART)" in IEEE 802.16j-06_013 document

We suggest to merging this section with the previous section 2.1.2.2, since both of them indicate the "Type-D BS-RS; RS-RS, LOS (ART-ART)" path-loss environment.

5. Comment on "2.1.2.4 Type-E: BS↔RS, NLOS (ART-to-BRT) and 2.1.2.5 Type-E: RS↔RS, NLOS (ART-to-BRT)" in IEEE 802.16j-06_013 document

We propose to combine these two sections "2.1.2.4 Type-E: BS↔RS, NLOS (ART-to-BRT)" and "2.1.2.5 Type-E: RS↔RS, NLOS (ART-to-BRT)" to one section called "2.1.2.3 Type-E: BS↔RS; RS↔RS; BS↔MS; RS↔MS, LOS/NLOS (ART-to-BRT) for suburban macro-cell scenario". The detailed suggestions are as following:

--Start of the Text--

2.1.2.3 Type-E LOS/NLOS (ART-to-BRT) for suburban macro-cell scenario

The following path-loss model is considered for Type-E LOS/NLOS medium suburban macro-cell scenario. In this scenario, one of transmit or receive antenna is above rooftop, and the other one is below rooftop. We adapt WINNER C1 scenario (suburban macro-cell model) given as

For LOS case:

$$\begin{cases} PL(d) = 23.8\log_{10}(d) + 41.6 \text{ dB} & 30m < d < d_B \\ PL(d) = 40.0\log_{10}(d/d_B) + 41.6 + 23.8\log_{10}(d_B) \text{ dB} & d_B < d < 5km \end{cases}$$

Where $d_B = 4\frac{h_t \cdot h_r}{\lambda}$

h_t is the height of the antenna which is above rooftop, h_r is the height of the antenna which is below rooftop, and λ is the carrier wavelength.

The formula above can be adapted for the frequencies between 2GHz and 6 GHz by replacing the constant 41.6 by a factor

$$C(f) = 33.2 + 20\log_{10}(f_C / (2\cdot 10^9))$$

For NLOS case:

$$PL(d) = 40.2\log_{10}(d) + 27.7 \text{ dB} \qquad for \quad 50m < d < 5km$$

Where d is in meters and d_B is the breakpoint also in meters.

--End of the Text--

Note that we may also consider the feasibility of the COST231-Hata model for this Type-E environment.

6. Comment on section "2.1.2.5 Type-E:…" in IEEE 802.16j-06_013 document

We propose to change "2.1.2.5 Type-E:…" to "2.1.2.4 Type-F NLOS (ART-BRT) for urban macro-cell scenario". We adapt WINNER C2 model (urban macro-cell model) and the details are given as following:

---Start of the Text---

2.1.2.4 Type-F: BS-RS, BS-MS, RS-RS, RS-MS, NLOS (ART-BRT) for urban macro-cell scenario

The following path-loss model is considered for Type-F NLOS scenario:

$$Pathloss(d) = 38.4 + 35 \cdot \log_{10}(d) \text{ dB}$$

where d is the distance in meter and 50m < d < 5km.

For this scenario, NLOS transmission is the general case. We may also use 2GHz COST231-Hata model with free-space correction to model path-loss around 5 GHz for Type-F urban macro-cell scenario. When using different carrier frequency, the following frequency correction factor can be added in previous path-loss equation:

$$C(f_c) = 20 \cdot \log_{10}(f_c/5)$$

Note that the results from COST231-Hata model and WINNER C2 measurement are valid between 100m-2000m.

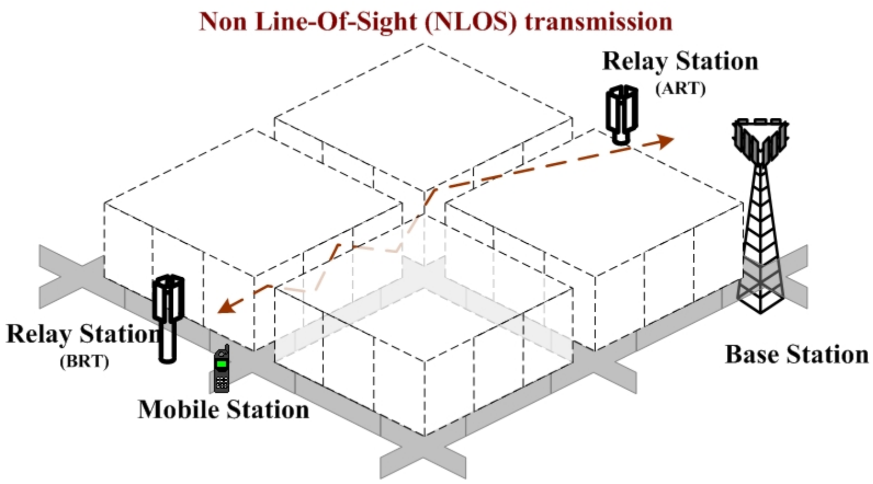

Figure.4 Type-F NLOS Urban Macro-cell Scenario

---End of the Text---

Note that we may also consider the feasibility of COST231-Walfish Ikegami rooftop diffraction model for this Type-F environment.

7. Comment on "2.1.2.6 Type-F: RS↔MS, LOS (BRT-to-BRT)" and "2.1.2.7 Type-F: RS ↔ MS, NLOS (BRT-to-BRT) in IEEE 802.16j-06_013 document

We suggest to merge the sections of "2.1.2.6 Type-F: RS↔MS, LOS (BRT-to-BRT)" and "2.1.2.7 Type-F: RS ↔ MS, NLOS (BRT-to-BRT) from IEEE 802.16j-06_013 baseline document together and become one section called "2.1.2.5.Type-G: RS-RS; RS-MS, LOS/NLOS (Urban Micro-cell BRT-to BRT model)". We suggest using WINNER B1 LOS/NLOS scenario (urban micro-cell model) and removing the Berg's model due to its high complexity for simulation. The details WINNER B1 model is as following:

--Start of the Text--

For LOS case as in Figure 6:

$$PL(d) = 22.7\log_{10}(d) + 41.0 \text{ dB} \qquad \textit{for } \; 10m < d < 650m$$

For NLOS case as in Figure 7:

$$PL(d) = 0.096 \cdot d_1 + 65 + (28 - 0.024 \cdot d_1) \cdot \log_{10}(d_2) \text{ dB} \qquad \textit{for } \; 10m < d_1 < 550m, \; w/2 < d_2 < 450m$$

Where d, w, d_1, d_2 are in meters and w is LOS street width and assumes it width is 30 m, d_1 is the distance along main street, d_2 is distance along perpendicular street and the carrier frequency is 5 GHz. This is a realistic and simple model comparing to Berg's model.

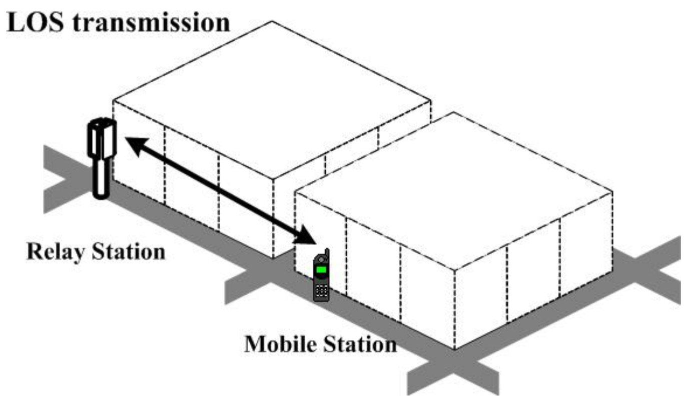

Figure.6 Type-G LOS Scenario

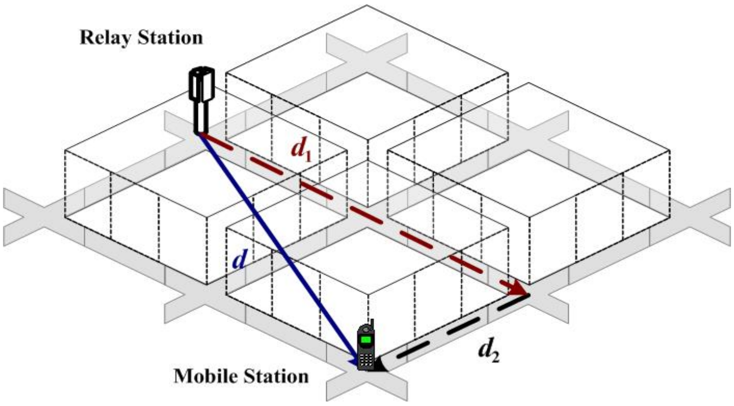

Figure7. Type-G NLOS Scenario

--End of the Text--

8. Comment on "2.1.2.8 Type-G Indoor Office Environment Path-loss Model"

We propose to change" 2.1.2.8 Type-G indoor office environment path-loss model" to "2.1.2.6 Type-H indoor office environment path-loss model". We suggest using WINNER A1 LOS/NLOS to replace the ITU model. The detailed WINNER A1 model is as following:

---Start of the Text---

The path-loss model considered for Type-H indoor office environment is:

For LOS case:

$$PL(d) = 18.7 \cdot \log_{10}(d) + 46.8 \text{ dB} \qquad for \quad 3m < d < 100m$$

For NLOS case:

$$PL(d) = 36.8\log_{10}(d) + 38.8 \text{ dB} \qquad for \quad 3m < d < 100m$$

Where d is in meters and the carrier frequency is 5 GHz.

---End of the Text---

9. Propose to add "2.1.2.7 LOS Probability"

We propose to add the LOS probability section as following:

---Start of the Text---

2.1.2.7 LOS Probability

In path-loss Type-E, Type-G and Type-H, the radio link may be either LOS (Line-Of-Sight) or NLOS (Non Line-Of-Sight).

For Type-E, the relay station or mobile station below the rooftop may have mobility. Therefore, the following equation for LOS probability [3] should be considered when simulation.

$$P_{LOS}(d) = \exp(-\frac{d}{500m})$$

For Type-G, both node-antennas are below rooftop. Therefore, the following equation for LOS probability [3] should be considered in simulation.

$$P_{LOS}(d) = \begin{cases} 1 & d \le 15m \\ 1-\left(1-\left(1.56-0.48\cdot\log_{10}(d)\right)^3\right)^{1/3} & d > 15m \end{cases}$$

where $d = \sqrt{d_1^2 + d_2^2}$, and d_1 and d_2 are like in Figure 7.

For Type-H, indoor office environment, the following equation for LOS probability [3] should be considered when simulation.

$$P_{LOS}(d) = \begin{cases} 1 & d \le 2.5m \\ 1 - 0.9 \cdot (1 - (1.24 - 0.61 \cdot \log_{10}(d))^3)^{1/3} & d > 2.5m \end{cases}$$

---End of the Text---

10. Comment on "2.2.1 Standard deviation of the shadow fading"

We propose to use the following Table:

---Start of the Text---

The standard deviations from Type-E to Type-H are defined from WINNER model [3].

	Type-A	Type-B	Type-C	Type-D	Type-E		Type-F	Type-G		Type-H	
				LOS	LOS	NLOS	NLOS	LOS	NLOS	LOS	NLOS
Std (dB)	10.6	9.6	8.2	3.4	4.0/ 6.0	8.0	8.0	2.3	3.1	3.1	3.5

---End of the Text---

11. Comment on "2.2.3 Tap-delay-line channel model" and "2.2.3.1. Multipath fading model parameters" in IEEE802.16j-06/013

Since we have not confirmed on which path-loss model for MMR system, we may not be able to use SUI model as a default model for multipath fading model. We propose to take the SUI model out until 802.16j working group resolve these concerns. Another consideration maybe is that WINNER multipath is MIMO based measurements at 100MHz and 2 or 5 GHz and SUI is SISO based model.

REFERENCES

[1] IEEE 802.16j-06/013, "Multi-hop Relay System Evaluation Methodology (Channel Model and Performance Metric)", September 2006.

[2] IEEE 802.16a-03/01 "Channel Models for Fixed Wireless Applications", June 2003.

[3] IST-2003-507581 WINNER D5.4 v1.4, "Final Report on Link Level and System Level Channel Models", November 2005. https://www.ist-winner.org/