Comments on IEEE 802.16j Path-loss Models in IEEE802.16j-06/013

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Base Document:

IEEE 802.16j-06/013

Purpose:

Propose modifications on channel models in baseline document

Introduction

- This document is a response to chair's call for comments on IEEE 802.16j-06/013 [1]
  - This contribution proposes the modifications on channel models in the baseline document
  - Categories of channel models are reorganized
    - Categories for propagation ART-to-BRT are merged
    - New category for propagation ART-to-BRT is proposed for urban/suburban environment

Channel model categories in baseline document

Category	Links	Description		Reference	Note
Type A	BS–MS	Hilly terrain with moderate-to-heavy tree densities		Section 2.1.2.1	IEEE 802.16 Type A model
Type B		Intermediate path-loss condition			IEEE 802.16 Type B model
Type C		Flat terrain with light tree densities			IEEE 802.16 Type C model
Type D	BS–RS RS–RS	Both node-antennas (BS/RS) above rooftop	LOS NLOS	Section 2.1.2.2	Modified IEEE 802.16 model
Type E	BS–RS RS–RS RS–MS	Only one node-antenna (BS/RS) above rooftop	NLOS	Section 2.1.2.4	Modified IEEE 802.16 model
Type F	RS–RS RS–MS	Both node-antennas (BS/RS) below rooftop	LOS	Section 2.1.2.5	Advanced LOS
			NLOS	Section 2.1.2.6	Berg/WiNNER
Type G	*RS–RS* *RS–MS*	*Indoor Office*	*NLOS*	*Section 2.1.2.7*	*ITU model*

Features of the categories in baseline document

- Category A through E use same path loss model (Erceg/Greenstein model)
  - BS-MS(NLOS) model is divided into three categories (A, B, C)
  - BS-RS/RS-RS/RS-MS(NLOS) model is considered in three environment but it has only one category (E)
  - Path loss (PL) is estimated by the following equation:

    $$PL = A + 10 \cdot \gamma \cdot \log10(d/d0) + \Delta PLf + \Delta PLh$$

  - Only antenna height correlation factors (ΔPLh) differ among categories
    - $\Delta PLh = -10.8 \cdot \log10(h/2)$ dB ; for Category A and B
    - $\Delta PLh = -20 \cdot \log10(h/2)$ dB ; for Category C
    - $\Delta PLh = -10 \cdot \log10(h/3)$ dB ; for Category D, $h <= 3m$
    - $\Delta PLh = -20 \cdot \log10(h/3)$ dB ; for Category D, $h > 3m$
    - $\Delta PLh = -10.8 \cdot \log10(h/2)$ dB ; for Category E, Terrain Type A and B
    - $\Delta PLh = -10 \cdot \log10(h/3)$ dB ; for Category E, Terrain Type C, $h <= 3m$
    - $\Delta PLh = -20 \cdot \log10(h/3)$ dB ; for Category E, Terrain Type C, $h > 3m$

  - MS antenna height for categories A, B, C is between 2 and 10m
    - MS antenna height should be around 1.5 m

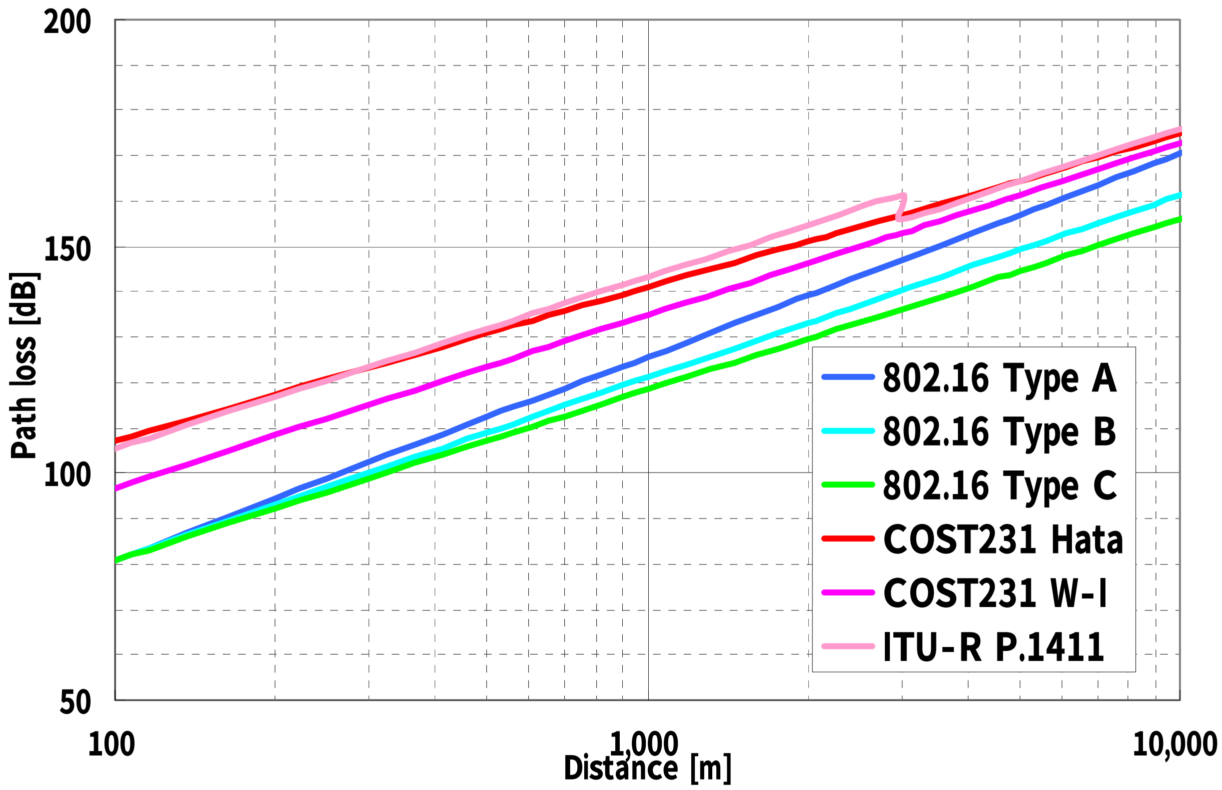
Observation of the categories in baseline document

- Categories in baseline document lacks urban/suburban mobile propagation model such as COST231 Walfisch-Ikegami model, COST231 Hata model or ITU-R P.1411 for BS-MS.

- Urban mobile propagation model will be required for MMR performance evaluations
  - Urban mobile propagation model has generally larger path loss compared to models for FWA (IEEE 802.16 models)

Example of path loss curves

Distance vs. path loss



Conditions

Carrier frequency	2,500 MHz
BS antenna height	50 m
MS antenna height	1.5 m
Average building height	30 m
Average building separation	50 m
Street width	25 m
Length of path covered by buildings	90% of path from BS to MS
Area for COST231 Hata	Metropolitan center

Proposed modifications

- Merge categories for ART-to-BRT model
  - –Category E is merged with categories A,B,C
    - $\Delta PLh = -10.8 \cdot \log10(h/2)$ dB ; *for Category A and B*
    - $\Delta PLh = -10 \cdot \log10(h/3)$ dB ; *for Category C, h <=3m*
    - $\Delta PLh = -20 \cdot \log10(h/3)$ dB ; *for Category C, h > 3m*
  - –Other modifications for categories A,B,C
    - Extend the range of MS antenna height for h >= 1m
- Add new category for ART-to-BRT model
  - –Add urban mobile propagation model for ART-to-BRT propagation
  - –Adopt COST231 Walfisch-Ikegami/Hata model for urban/suburban environment

Categories in the baseline document

Cat.	Links	Description		Note
A	BS–MS	Hilly terrain with mod.-to-heavy tree densities		IEEE 802.16 Type A
B	BS–MS	Intermediate path-loss condition		IEEE 802.16 Type B
C	BS–MS	Flat terrain with light tree densities		IEEE 802.16 Type C
D	BS–RS RS–RS	Both node-antennas (BS/RS) above rooftop	LOS NLOS	Modified IEEE 802.16
E	BS–RS RS–RS RS–MS	Only one node-antenna (BS/RS) above rooftop	NLOS	Modified IEEE 802.16
F	RS–RS RS–MS	Both node-antennas (BS/RS) below rooftop	LOS	Advanced LOS
			NLOS	Berg/WiNNER
G	*RS–RS RS–MS*	*Indoor Office*	*NLOS*	*ITU model*

Proposed categories

Cat.	Links	Description			Note
A	BS–MS BS–RS RS–RS RS–MS	Only one node-antenna above rooftop	Hilly terrain with moderate-to-heavy tree densities	NLOS	IEEE 802.16 Type A
B			Intermediate path-loss condition	NLOS	IEEE 802.16 Type B
C			Flat terrain with light tree densities	NLOS	Modified IEEE802.16 Type C
D	BS–MS BS–RS RS–RS RS–MS	Only one node-antenna above rooftop	Urban/suburban environment	NLOS	COST231 Walfisch-Ikegami COST231 Hata ITU-R P.1411
E	BS–RS RS–RS	Both node-antennas (BS/RS) above rooftop		LOS NLOS	Modified IEEE 802.16
F	RS–RS RS–MS	Both node-antennas (BS/RS) below rooftop		LOS	Advanced LOS
				NLOS	Berg/WiNNER
G	*RS–RS RS–MS*	*Indoor Office*		*NLOS*	*ITU model*

Proposed path loss equations (1/2)

- Type A, B, C

$PL = A + 10 \cdot \gamma \cdot \log_{10}(d / d_0) + \Delta PL_f + \Delta PL_h + s\ dB$

where $d_0 = 100m$ and $d > d_0$. $A = 20 \cdot \log_{10}(4\pi d_0 / \lambda)$ and $\gamma = (a - b \cdot h_b + c / h_b)$. λ is the wavelength in meter and h_b is the base station antenna height, which is between 10m and 80m. "*s*" is the log-normal shadow fading component in dB. Three propagation scenarios are categorized as

Terrain Type A: Hilly terrain with moderate-to-heavy tree densities

Terrain Type B: Intermediate path-loss condition

Terrain Type C: Flat terrain with light tree densities

The corresponding parameters for each propagation scenario are

Parameters for the Type A/B/C

Model Parameter	Terrain Type A	Terrain Type B	Terrain Type C
a	4.6	4	3.6
b	0.0075	0.0065	0.005
c	12.6	17.1	20

Moreover, the correction factors for carrier frequency (ΔPL_f) and receive antenna height (ΔPL_h) are:

$\Delta PL_f = 6 \cdot \log_{10}(f / 2000)$ dB

where f is the carrier frequency in MHz.

$\Delta PL_h = -10.8 \cdot \log_{10}(h / 3)\ dB$; for Terrain Type A and B

$\Delta PL_h = -10 \cdot \log_{10}(h / 3)\ dB$; for Terrain Type C, $h <= 3m$

$\Delta PL_h = -20 \cdot \log_{10}(h / 3)\ dB$; for Terrain Type C, $h > 3m$

where h is the receive antenna height between 1m and 10m.

Proposed path loss equations (2/2)

- Type D

  (1) COST 231 Hata model

$$PL = 46.3 + 33.9 \cdot \log_{10}(f) - 13.82 \cdot \log_{10}(h_b) - a(h) + (44.9 - 6.55 \cdot \log_{10}(h_b)) \cdot \log_{10}(d/1000) + Cm \quad dB$$

where:

$a(h) = (1.1 \cdot \log_{10}(f) - 0.7) \cdot h - (1.56 \cdot \log_{10}(f) - 0.8)$

$Cm = 0$ for medium sized city and suburban centers with medium tree density

$= 3$ for metropolitan centers

f is the carrier frequency in MHz

h_b is the base station antenna height in meter

h is the receive antenna height in meter

d is distance in meter

  (2) COST 231 Walfisch-Ikegame model

  See detail in section 4.4.1 of [3]

  (3) ITU-R P.1411

  See detail in section 4.2.1 of [4]

- Type E, F, G

  Use path loss equations for type D, F, G in [1], respectively

Reasons for modifications

- Merging categories A,B,C and category E
  - Categories A,B,C and category E (in [1]) refer same scenario and same path loss model
    - Only one node antenna is above the rooftop and the other one is below rooftop
    - IEEE802.16 model (Erceg/Greenstein model) is adopted
    - Only antenna height correlation factor differs among categories
  - Antenna height correlation factor should not depend on the type of the node
    - Consider if MS can works as RS, does path loss between BS and MS change?
  - Category E is moved into Categories A, B, C

- Adding new category
  - Urban/suburban model is not covered by [1]
  - Urban/suburban model is required to compare MMR performance with Mobile WiMAX performance
    - COST 231 suburban model is used in Mobile WiMAX performance evaluation
  - COST 231 Walfisch-Ikegami / COST 231 Hata models should be added in channel model categories
  - ITU-R P.1411 should be added in channel model categories
    - ITU-R P.1411 extends the frequency range of Walfisch-Ikegami model over 2GHz

References

[1]IEEE 802.16j-06/013: “Multi-hop Relay System Evaluation Methodology”, September, 2006
http://ieee802.org/16/relay/docs/80216j-06_013.pdf

[2]Mobile WiMAX forum, “Mobile WiMAX-Part I: A technical overview and performance evaluation”, June, 2006
http://www.wimaxforum.org/news/downloads/Mobile_WiMAX_Part1_Overview_and_Performance.pdf

[3]COST 231 Final report, “Digital Mobile Radio towards Future Generation Systems”
http://www.lx.it.pt/cost231/final_report.htm

[4]RECOMMENDATION ITU-R P.1411-3, “Propagation data and prediction methods for the planning of short-range outdoor radio communication systems and radio local area networks in the frequency range 300MHz to 100GHz”