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

Submission Title: [VLC channel modeling in Home, Cafe]

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Abstract: [Results of channel modeling simulation are presented. Home, Cafe are considered. The effect of FOV is also presented. And updated channel measurement results.]

Purpose: [Contribution to IEEE 802.15 SG-VLC]

VLC channel modeling simulation (Home, Cafe)

2008.09.10

Samsung Electronics

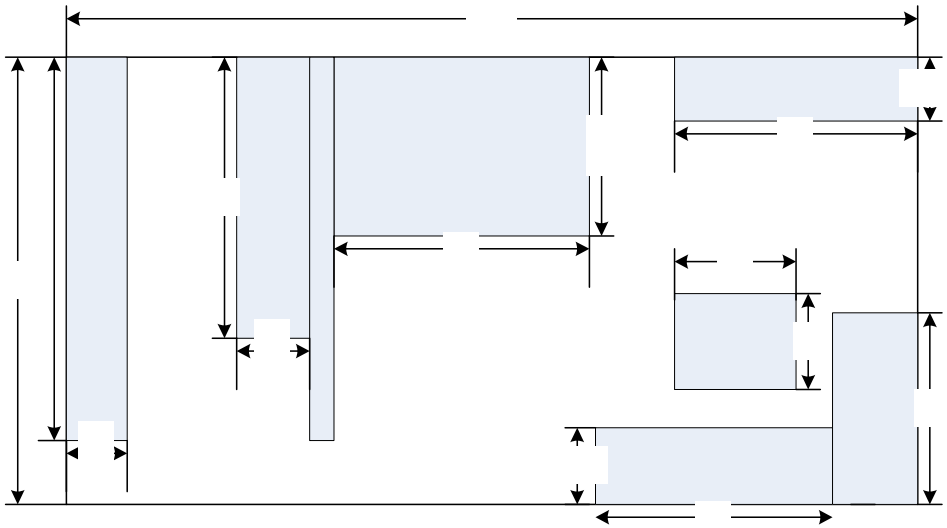
Contents

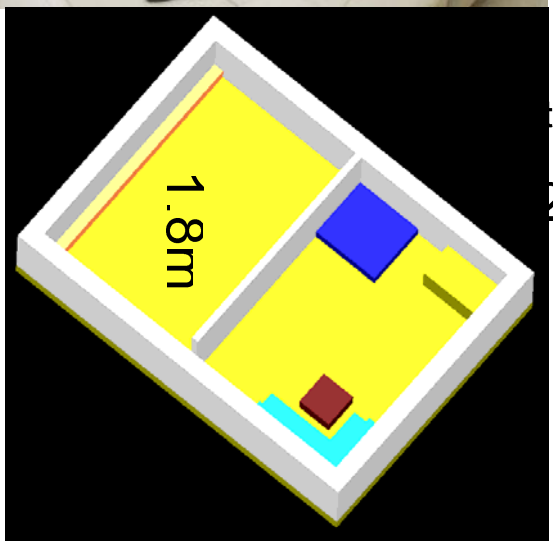
- Channel modeling in Home
  - 3D modeling, photon map, impulse response, Tapped delay line model
- Channel modeling in Cafe
- Channel modeling comparison (FOV 90° case)
- Future Works
- Updated VLC channel measurement results

VLC Channel Modeling Environments

	Size	Window	Distance between Tx	Indoor brightness
Home	Small	None	Short	Medium
Hospital	Small	None	Short	High
Café	Medium	Window	Long	Low
CD shop	Medium	None	Medium	Low
Museum	Large	Window	Long	Low
Office	Large	Window	Long	High

Home 3D Modeling





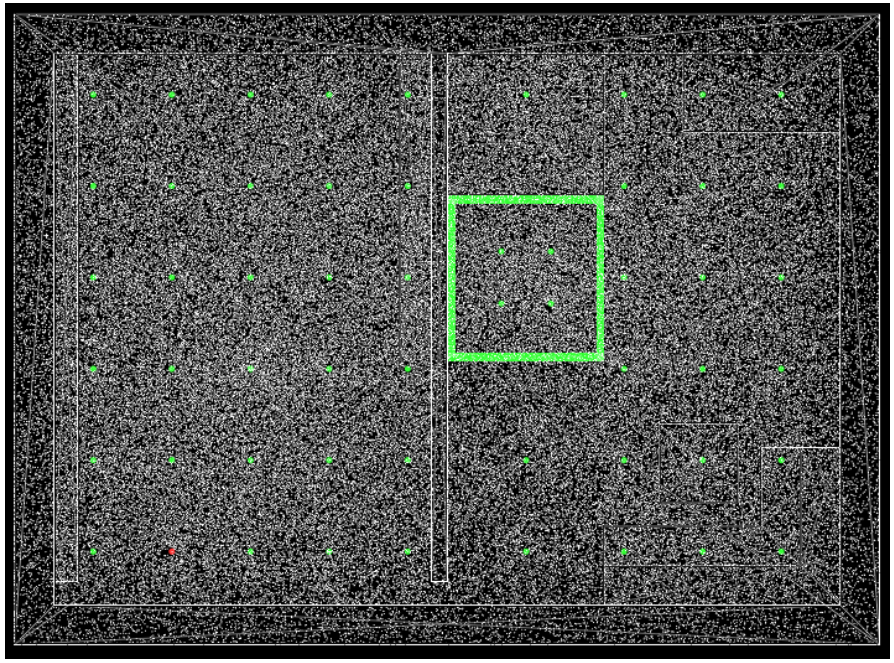
- Plane figure
  - 2 sofas
  - 2 tables
  - 1 exhibition table
  - 1 Sink
  - 1 bed
- Application
  - VL-LAN
  - Fixed to infra
  - Mobile to fixed

Simulation Parameters

Size	**7m × 10m × 2.5m**
Transmitted optical power	**100mW**
Number of Tx	**49 point sources, 4 rectangular sources**
Size of Tx	**Point source, Rectangular source(2m × 0.1m)**
Height of Tx	**2.5m**
Pattern of Tx	**180°**
Reflection type	**Specular / Mirror reflection**
Number of reflection	**3 times**
Reflection index (Based on color)	**Floor: 36% Ceil, Wall: 93% Table: 3% Sink: 93% Sofa: 48%**
Rx height	**0.5m, 1m**
Rx FOV	**60°**

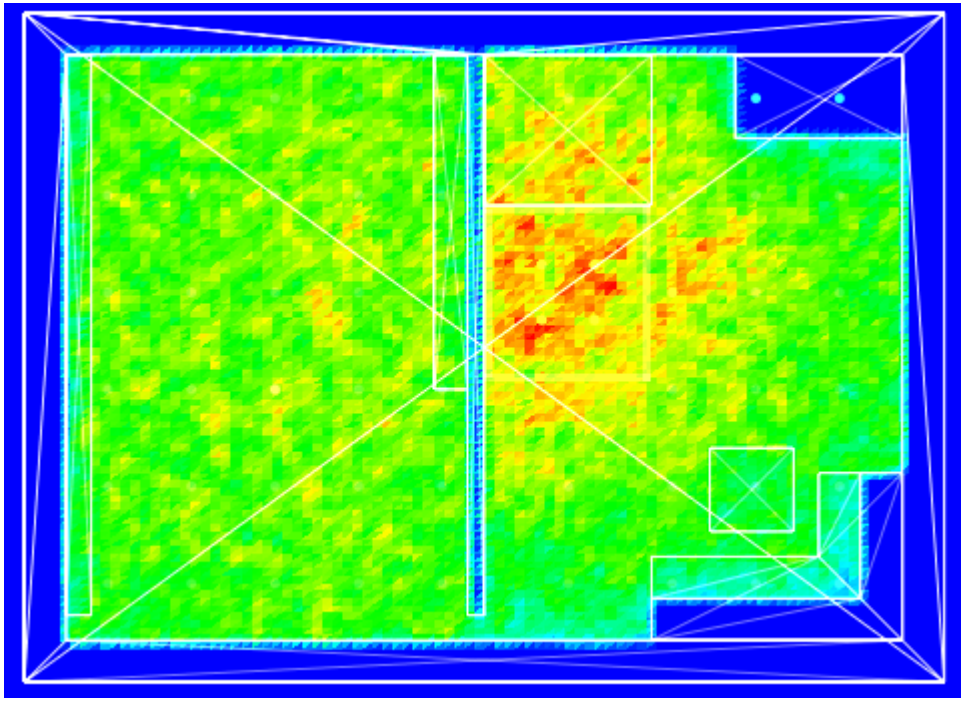
Photon Map

- Photon map of office environment
  - 4 rectangular LEDs
    - Green rectangular
    - 2m×0.1m
  - 49 point sources
  - 2 million photons
- Photon
  - White dot



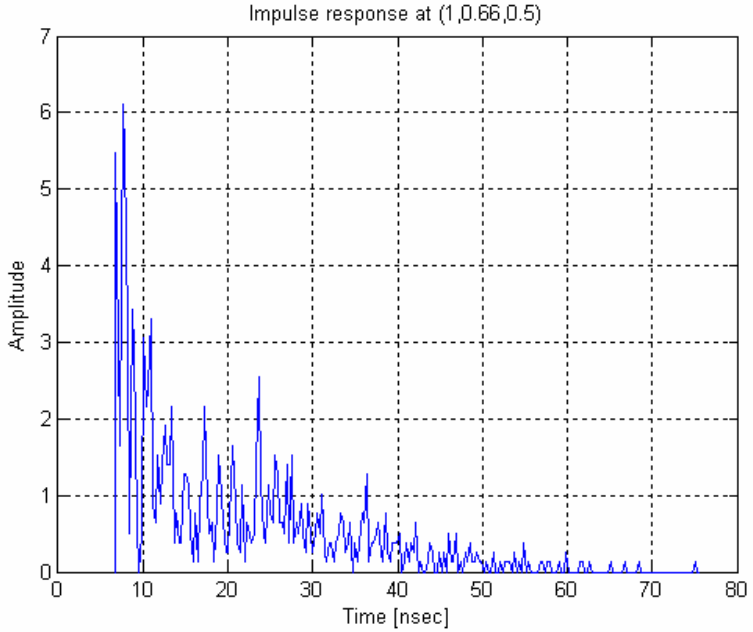
Simulation Result(1/3)

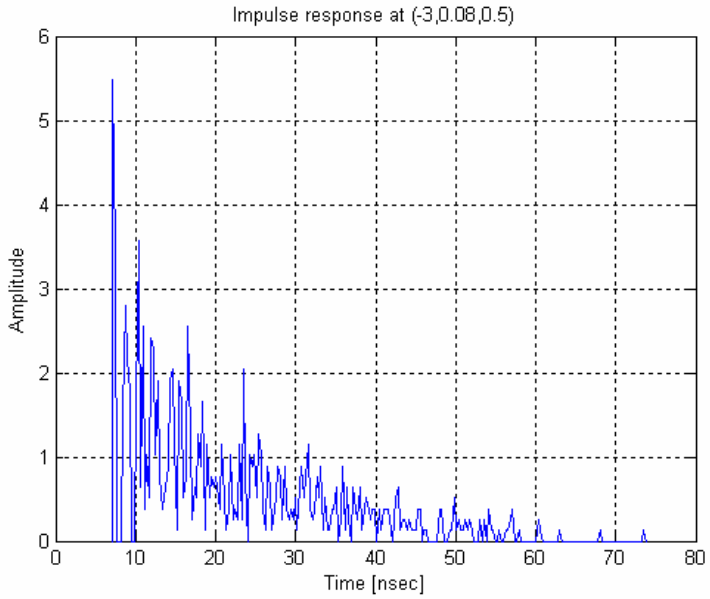
- Power mean at 0.5m
  - 0.5m is for application on the sofa
    - Because of less illumination, received power is smaller.
  - Under the rectangular sources
    - More power received



Simulation Result(2/3)

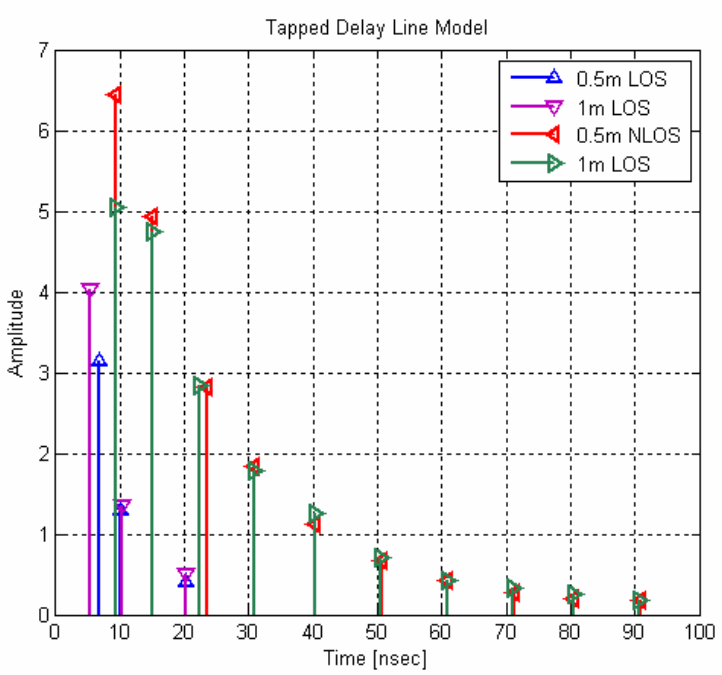
- Impulse response at (1,0.66,0.5)
  - Under the rectangular sources
- Impulse response at (-3,0.08,0.5)
  - In the kitchen
  - No rectangular source



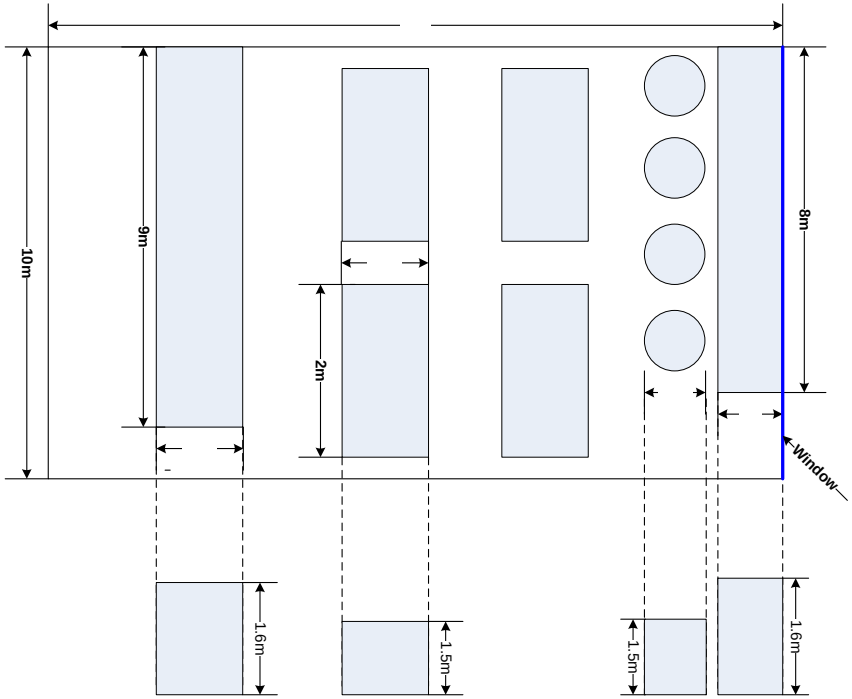


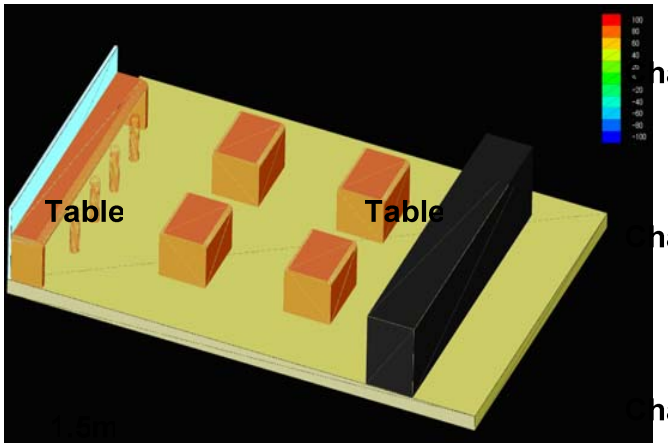
Simulation Result(3/3)

- TDL (Tapped Delay Line) model
  - Generally, communication channel is continuous time channel
  - Minimum unit delayed discrete time channel model from continuous time channel
    - 100 x 100 blocks
    - Only LOS channel blocks
    - 1 nsec unit for 1Gbps application case



Café 3D Modeling





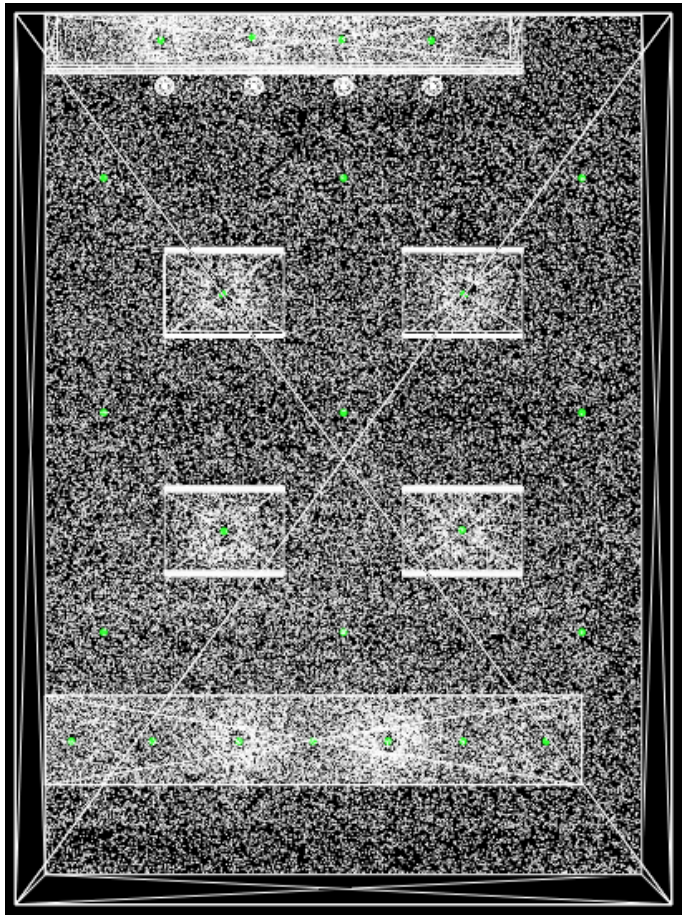
- Plane Figure
  - 4 Tables
  - 4 Chairs
  - 1 Exhibition table
  - 1 window table
- Application
  - VLC LAN
  - Wireless ordering system
- Cafe 3D modeling

Simulation Parameters

Size	**12.1m x 16.4m x 3.3m**
Transmitted optical power	**100mW**
Number of Tx	**25 Txs**
Size of Tx	**Point source**
Height of Tx	**2.1m, 2.5m**
Pattern of Tx	**180˚**
Reflection type	**Specular / Mirror reflection**
Number of reflection	**3 times**
Reflection index (Based on color)	**Floor: 12% Ceil: 24% Table: 24% Chair: 93% Exhibition table: 24% Window table: 24% Wall: 12% Window glass: 8%**
Rx height	**1.5m, 1.7m**
Rx FOV	**60˚**

Photon Map

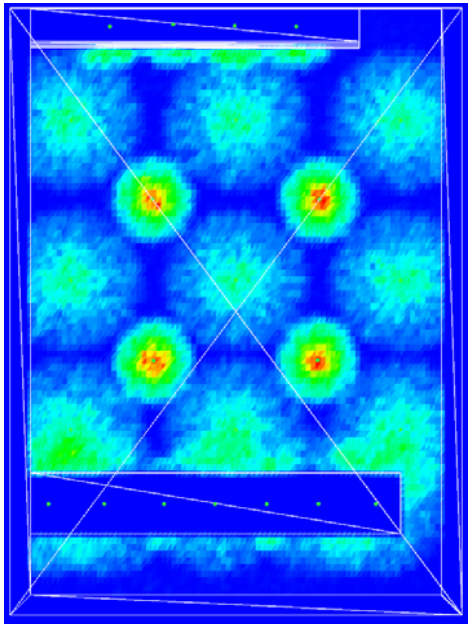
- Photon map of office environment
  - 25 point LEDs
  - 2 million photons
- Photon
  - White dot



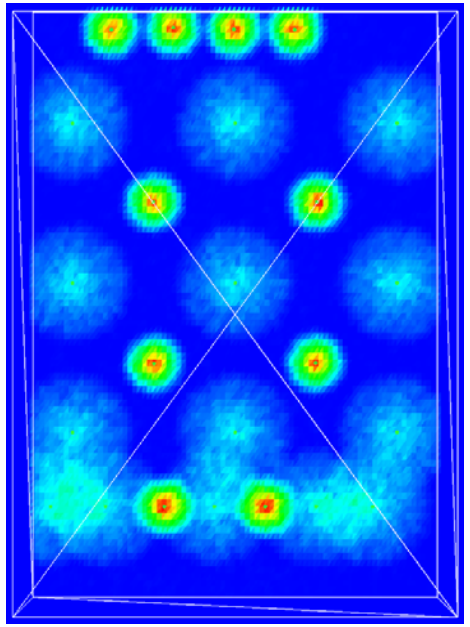
Simulation Result(1/3)

- Power mean at 1.5m and 1.7m
  - 25 LED Txs
    - 1.5m over the table
    - 1.7m over the window table and exhibition table

(a) 1.5m Table

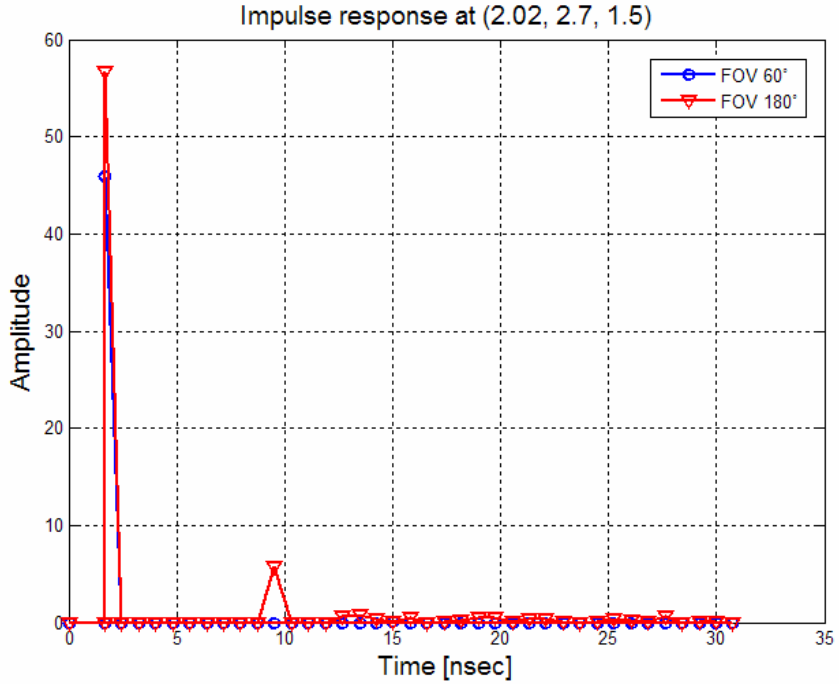


(b) 1.7m Window table



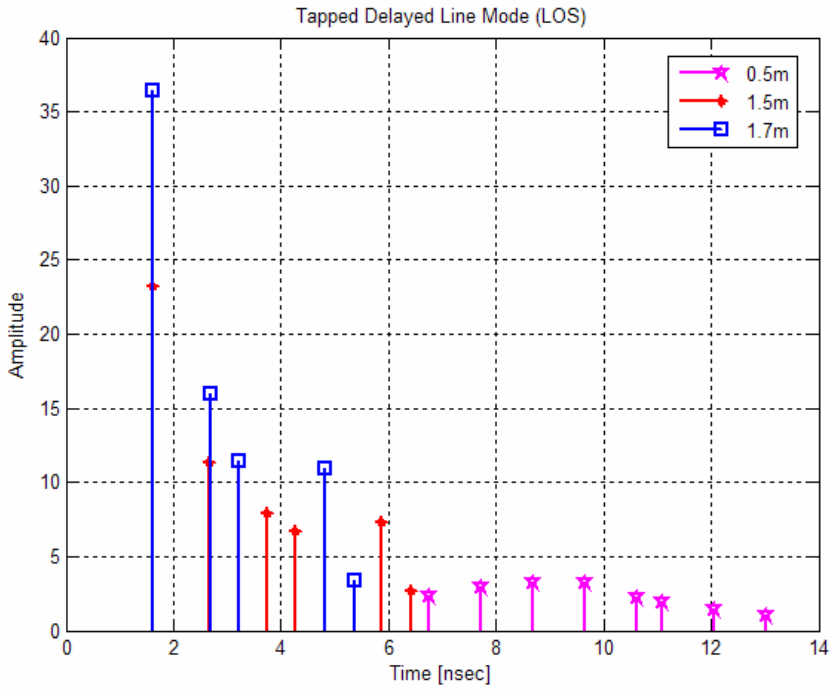
Simulation Result(2/3)

- Impulse response at (2.02, 2.7, 1.5)
  - Over the table
  - Little interference from other Txs because of FOV
    - FOV: 60°



Simulation Result(3/3)

- TDL (Tapped Delay Line) model
  - Generally, communication channel is continuous time channel
  - Minimum unit delayed discrete time channel model from continuous time channel
    - 100 x 100 blocks
    - Only LOS channel blocks
    - 1 nsec unit for 1Gbps application case
- Lower height, more taps
  - Cause of ISI
  - To reduce ISI, we can narrow FOV



Future Works

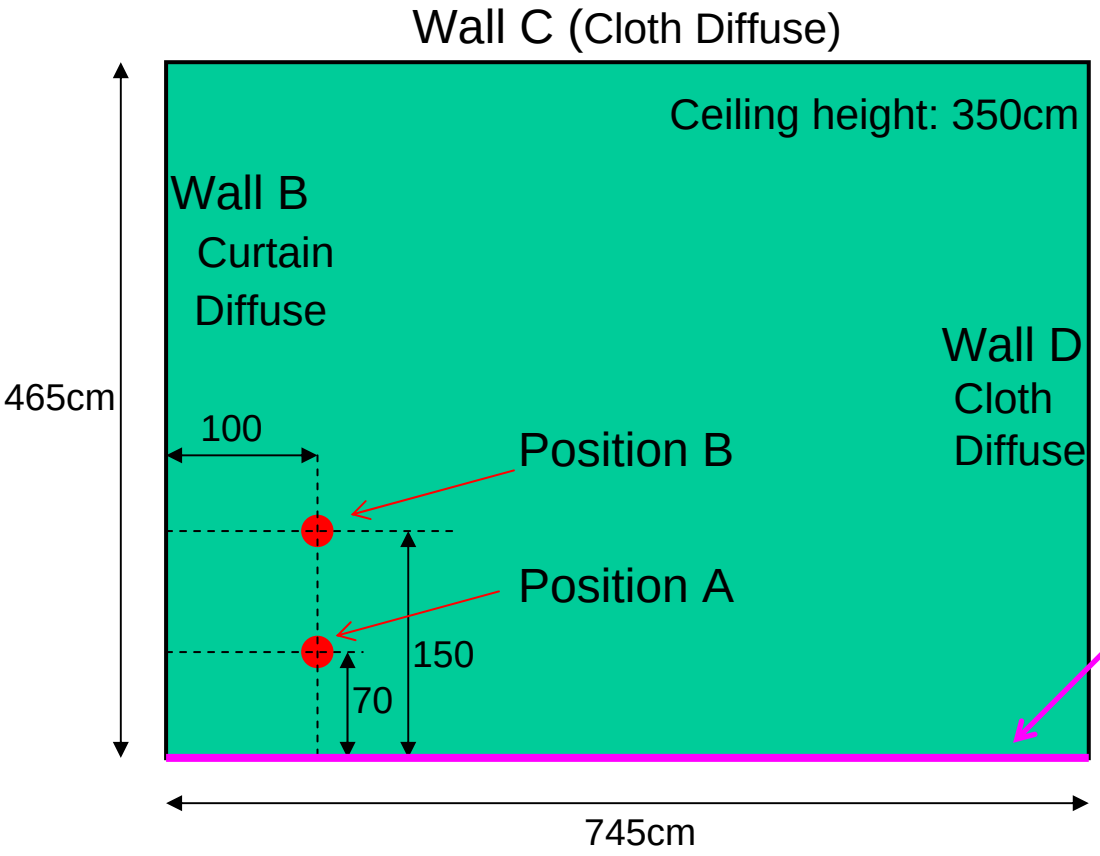
- Channel modeling simulation
  - RGB LED channel modeling
  - Reflection
    - Diffuse, Glossy reflection simulation

VLC channel measurement

- Samsung presented about “VLC channel measurement” in the previous meeting.
- We show the comparison between the Simulation & Measurement again for confirming the simulation accuracy.
- We corrected some simulation parameters for fitting the measurement situation.

  - Reflection Index : 8% -> 3%
  - FOV (Field of View): 45° -> 70°

Measurement Environment

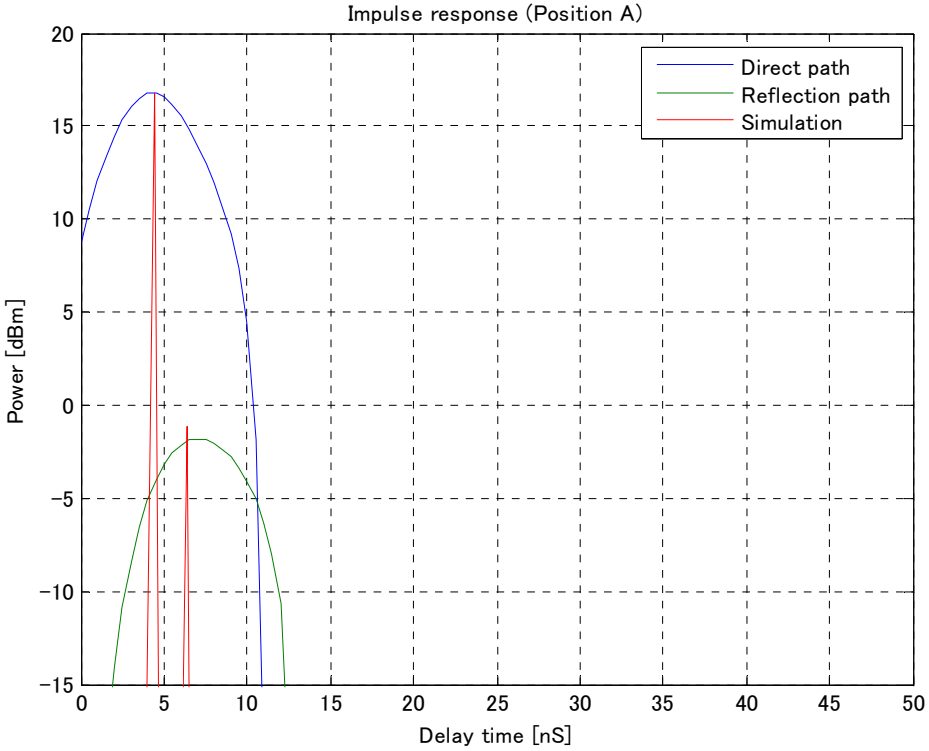


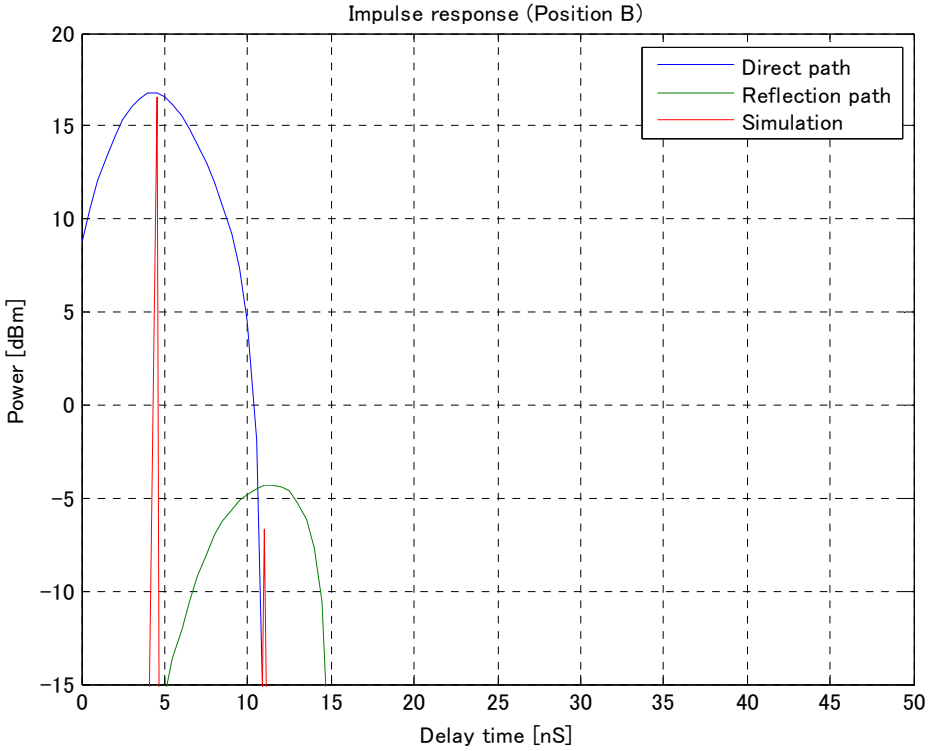
Position A
Tx(100, 75, 220) [cm]
Rx(100, 65, 90)

Position B
Tx(100, 155, 220) [cm]
Rx(100, 145, 90)

Wall A
Wood coated with varnish
Glossy/Specular Reflection
Reflection index : around 3%

Impulse response





Position A
Tx (100, 75, 220), Rx(100, 65, 90)

Position B
Tx (100, 155, 220), Rx(100, 145, 90)

*Simulation: Reflection index 3%, FOV 70degrees

Simulation vs. Measurement

	Simulation			Measurement		Difference	
	Delay time(ns)	Power (W)	Power ratio	Delay time(ns)	Power ratio	Delay time(ns)	Power ratio
Position A	4.455	0.047078	-17.85dB	4.2	-18.5dB	-0.255	-0.65dB
	6.432	0.000772		6.8		+0.368	
Position B	4.538	0.045843	-23.28dB	4.2	-21.1dB	-0.338	+2.17dB
	10.985	0.000216		11.5		+0.515	

*Simulation: Reflection index 3%, FOV 70degrees

Thank You~

Q&A