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

Submission Title: [VLC channel modeling in CD shop, Museum, Hospital]

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Source: [(1) Jaeseung Son, Dongjae Shin, Taehan Bae, Hyukchoon Kwon, Euntae Won]
Address [(1) Dong Suwon P.O. Box 105, 416 Maetan-3dong, Yeongtong-gu, Suwon-si, Gyeonggi-do, 443-742 Korea]
Voice:[(1)82-31-279-5285]
E-Mail:[(1)js1007.son@samsung.com]

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Abstract: [Results of channel modeling simulation are presented. CD shop, museum, hospital are considered. The effect of FOV is also presented.]

Purpose: [Contribution to IEEE 802.15 SG-VLC]

VLC channel modeling simulation (CD shop, Museum, Hospital)

2008.07.17

Samsung Electronics

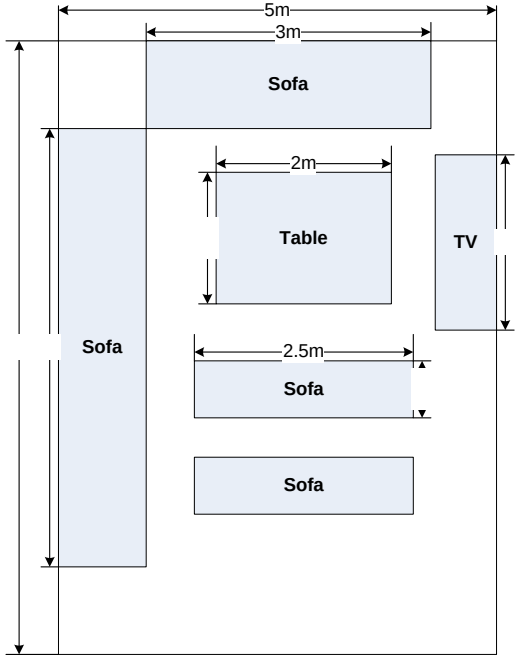
Contents

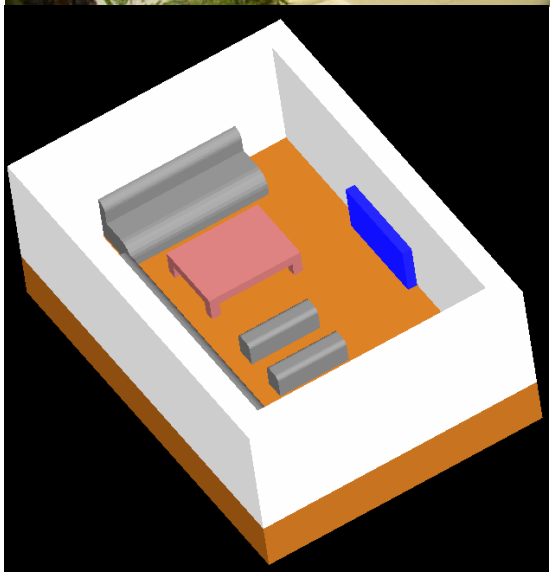
- Channel modeling in Hospital
  - 3D modeling, photon map, impulse response, Tapped delay line model
- Channel modeling in CD shop
- Channel modeling in Museum
- Channel modeling comparison (FOV 90° case)
- Future Works

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

Hospital 3D Modeling





- Plane Figure
  - 4 Sofas
  - 1 Table
  - 1 Tv
- Application
  - Information of private disease
  - Recent health trend

1.5m • 2m

3D modeling of Office

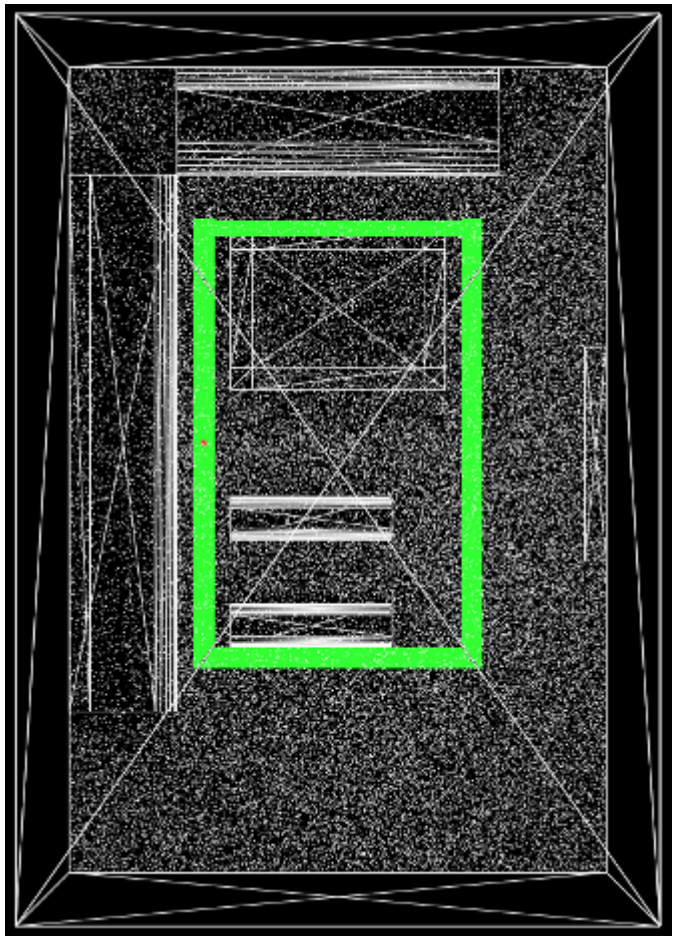
8m 5m

Simulation Parameters

Size	**8m × 5m × 3m**
Transmitted optical power	**100mW**
Number of Tx	**4 rectangular source**
Size of Tx	**4.2m×0.2m, 2.5m×0.2m**
Height of Tx	**3**
Pattern of Tx	**Uniform(2π)**
Reflection type	**Specular/Mirror reflection**
Number of reflection	**3 times**
Reflection index (Based on color)	**Sofa: 9% or 93% Table: 12% Tv: 36% Ground: 48% Ceiling: 48% Wall: 48%**
Rx height	
Rx FOV	**90°, 60° , 45°**

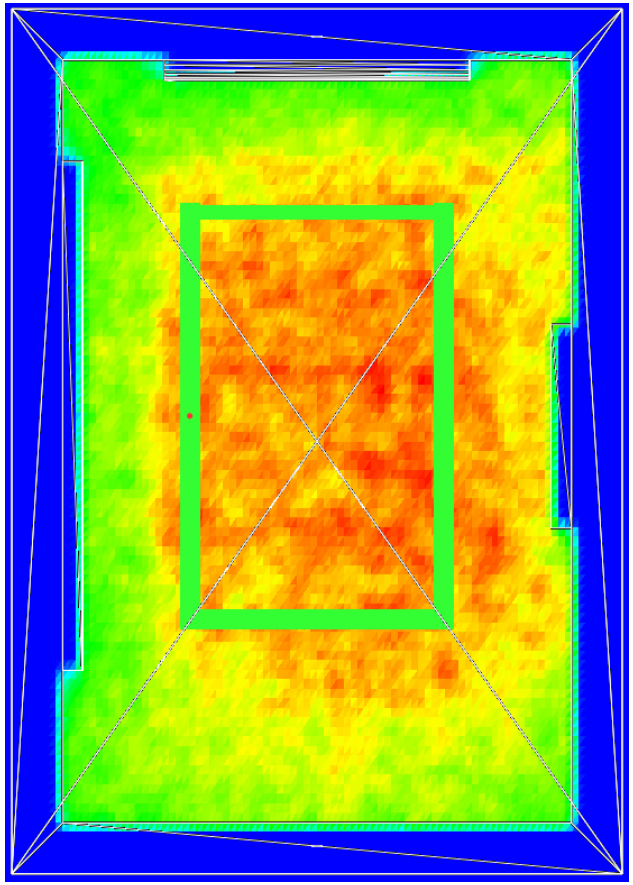
Photon Map

- Photon map of office environment
  - 4 rectangular LEDs
    - Green rectangular
    - 4.2m×0.2m, 2.5m×0.2m
  - 2 million photons
- Photon
  - White dot



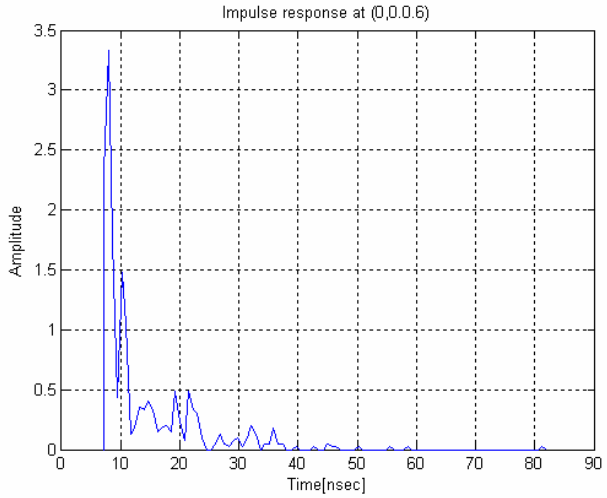
Simulation Result(1/3)

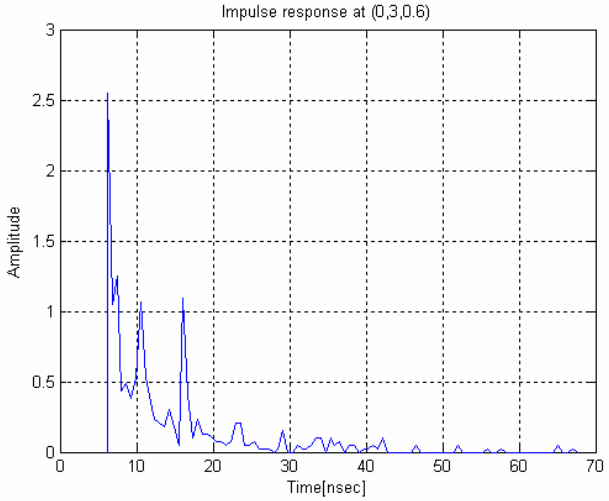
- Power mean at 0.6m
  - 0.6m in a case of handheld case
    - In center, more power received



Simulation Result(2/3)

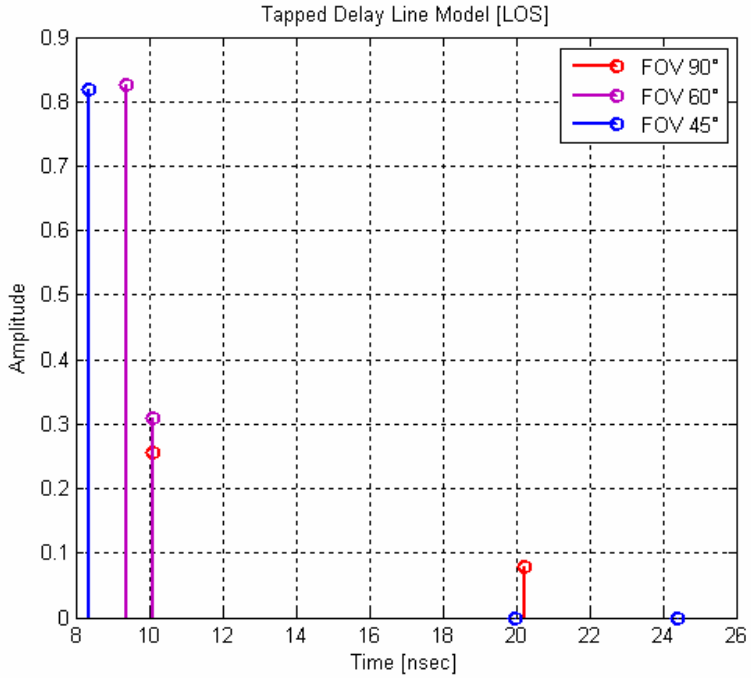
- Impulse response at (0,0,0.6)
  - Center of the room
  - Maximum power received
- Impulse response at (0,3,0.6)
  - On the sofa
  - Lower power received than center of the room



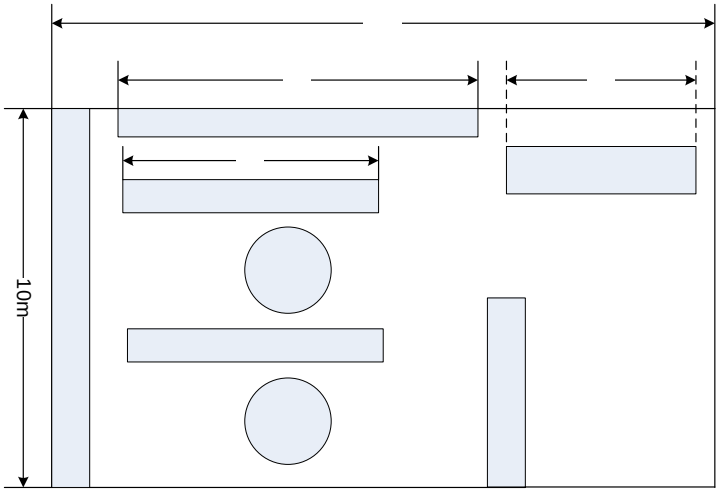


Simulation Result(3/3)

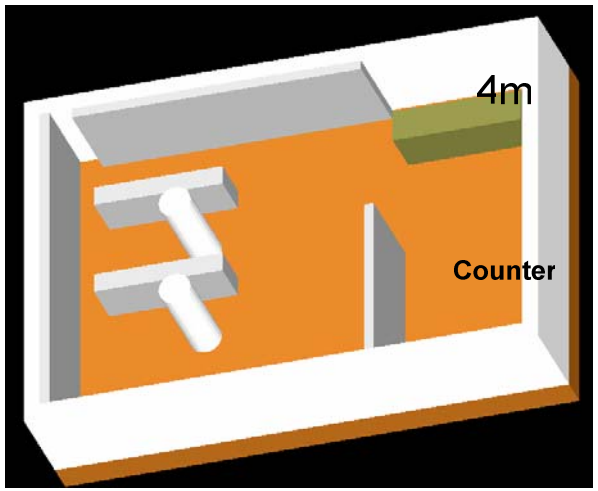
- TDL (Tapped Delay Line) model
  - Generally, communication channel is continuous time channel
  - Minimum unit delayed discrete time channel model from continuous time channel
    - 100 x 100 blocks
    - Only LOS channel blocks
    - 1 nsec unit for 1Gbps application case
- Effect of FOV
  - As FOV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



CD shop 3D Modeling



- Plane Figure
  - 5 show cases
  - 2 pillars
  - 1 counter
- Applications
  - Music streaming service
  - Music Video service



- 3D modeling of CD shop

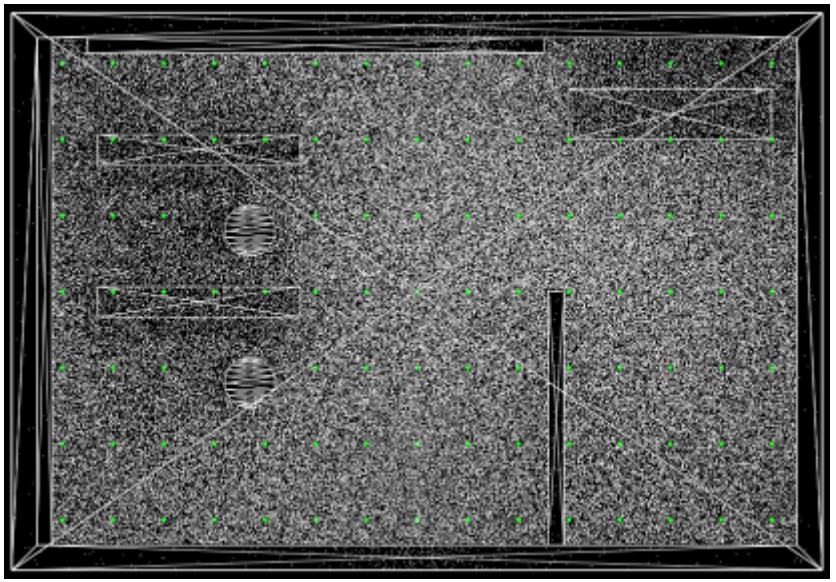
Simulation Parameters

Size	**10m×15m×3m**
Transmitted optical power	**100W**
Number of Tx	**101 Txs**
Size of Tx	**Point source**
Height of Tx	**3m**
Pattern of Tx	**Uniform(2π)**
Reflection type	**Specular/Mirror reflection**
Number of reflection	**3 times**
Reflection index (Based on color)	**Ground: 24% Show Case: 3% Pillar: 3% Counter: 3% Wall: 12% Ceiling: 12%**
Rx height	**1m**
Rx FOV	**90°, 60° , 45°**

Photon Map

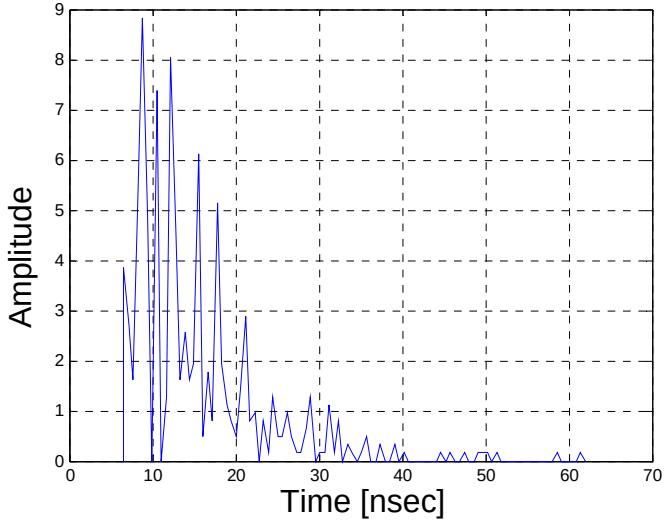
- Photon map of office environment
  - 101 Point LEDs (Green dots)
  - 1.5m distances between LED Txs
  - 2 million photons

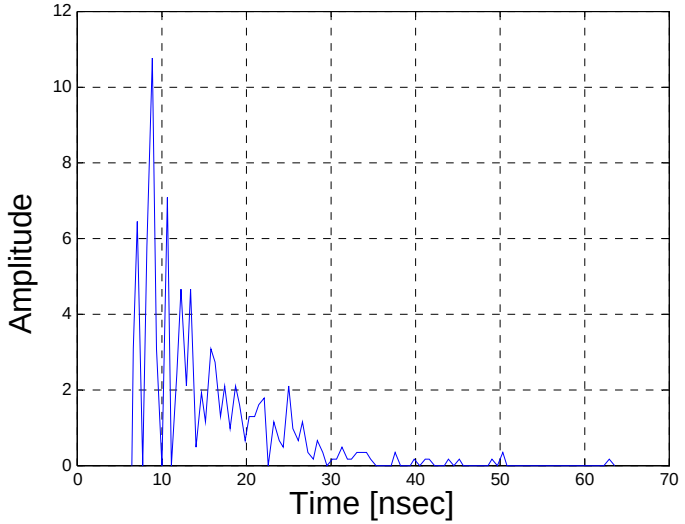
- Photon
  - White dot



Simulation Result(1/2)

- Impulse response at (3,1.5,1)
  - Under the light
- Impulse response at (0,-1.5,1)
  - In front of desk





Simulation Result(2/2)

- TDL (Tapped Delay Line) model
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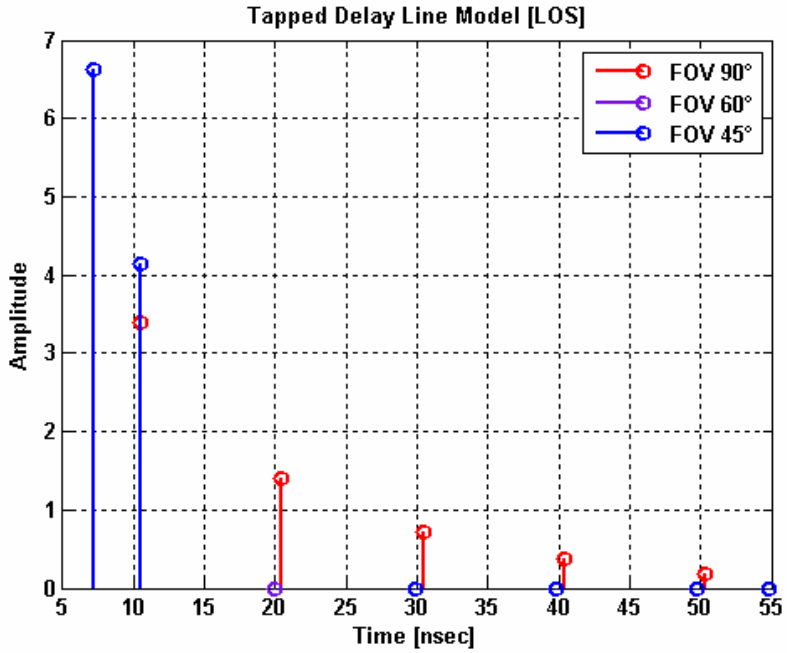
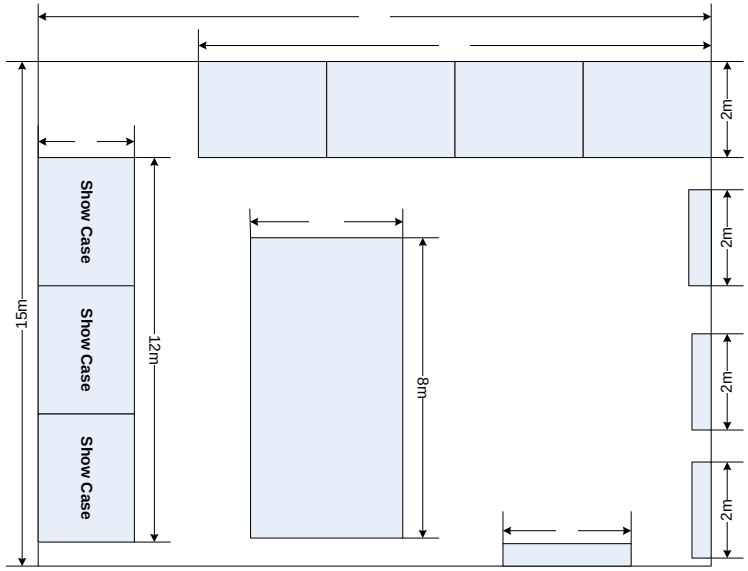
    - 100 x 100 blocks
    - Only LOS channel blocks
    - 1 nsec unit for 1Gbps application case
- Effect of FOV
  - As FOV bigger, more tap received
  - To reduce ISI, we can narrow FOV.

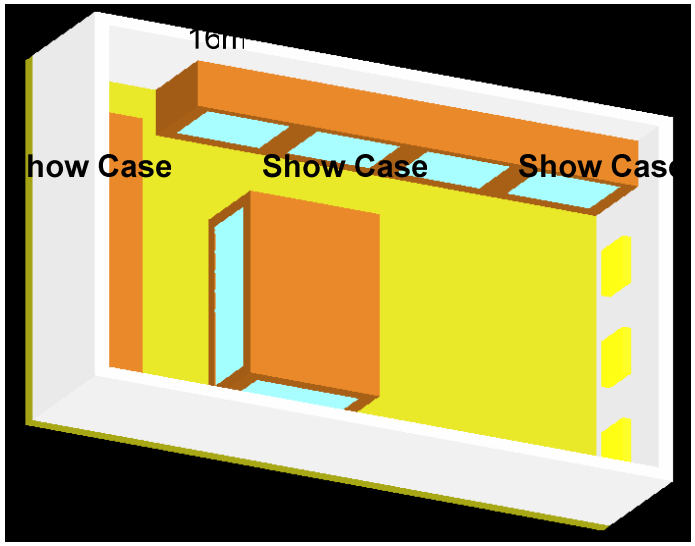


Museum 3D Modeling



Show Case

- Plane Figure
  - 8 show cases for cultural assets
  - 4 pictures
- Application
  - Audio, Video guide service



- 3D modeling of museum

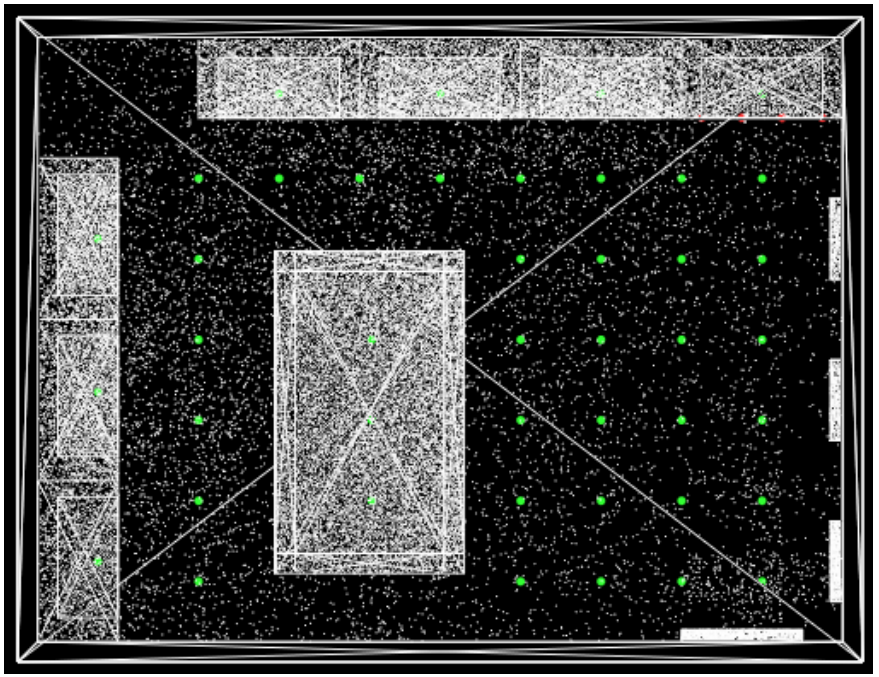
Show Case

Simulation Parameters

Size	**15m×20m×4.5m**
Transmitted optical power	**100mW**
Number of Tx	**42 Txs**
Size of Tx	**Point Source**
Height of Tx	**4.4m**
Pattern of Tx	**Uniform(2π)**
Reflection type	**Specular/Mirror reflection**
Number of reflection	**3 times**
Reflection index (Based on color)	**Ground: 24% Wall: 93% Ceiling: 24%**
Rx height	**1m**
Rx FOV	**90˚, 60˚ , 45˚**

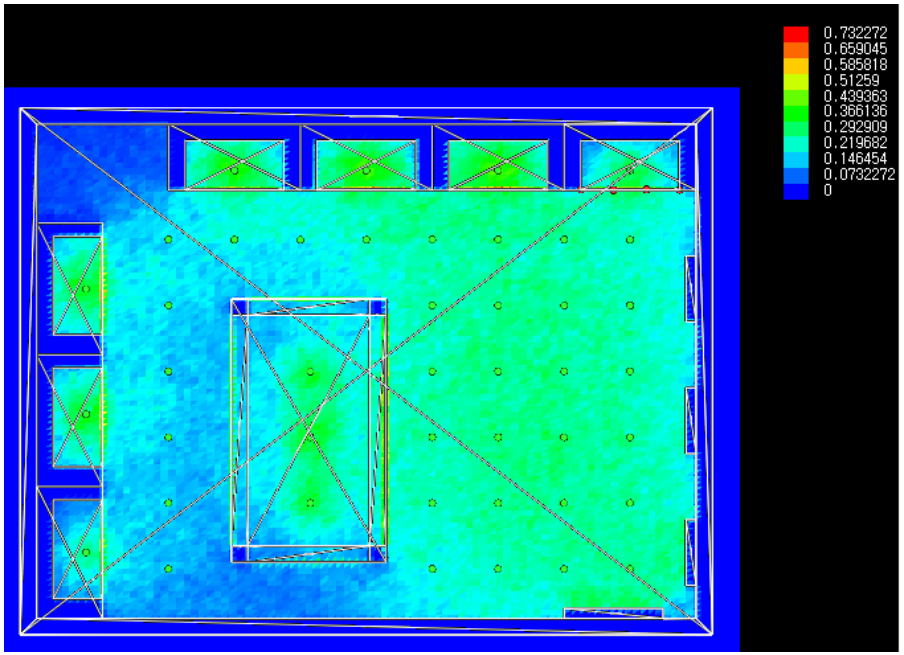
Photon Map

- Photon map of office environment
  - 42 Point LEDs (Green dots)
  - 2m distances between LED Txs
  - 2 million photons
- Photon
  - White dot



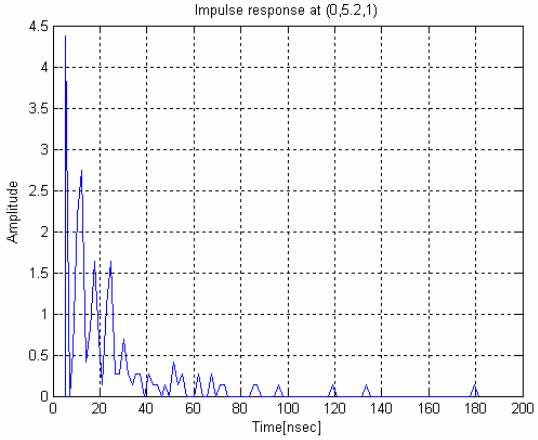
Simulation Result(1/3)

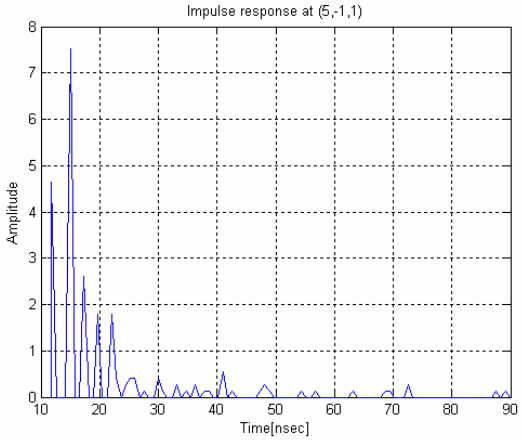
- Power mean at 1m
  - 1m in a case of handheld case

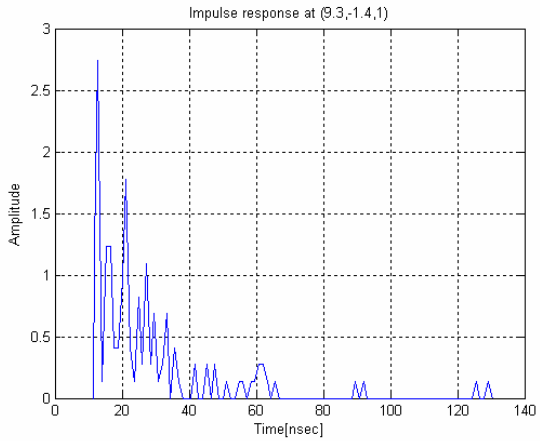


Simulation Result(2/3)

- Impulse response at (0,5.2,1)
  - In front of cultural assets
  - Half of power received comparing with power of under the light
- Impulse response at (5,-1,1)
  - Under the LED light
  - Maximum power received
- Impulse response at (9.3,-1.4,1)
  - In front of picture
  - Minimum power received







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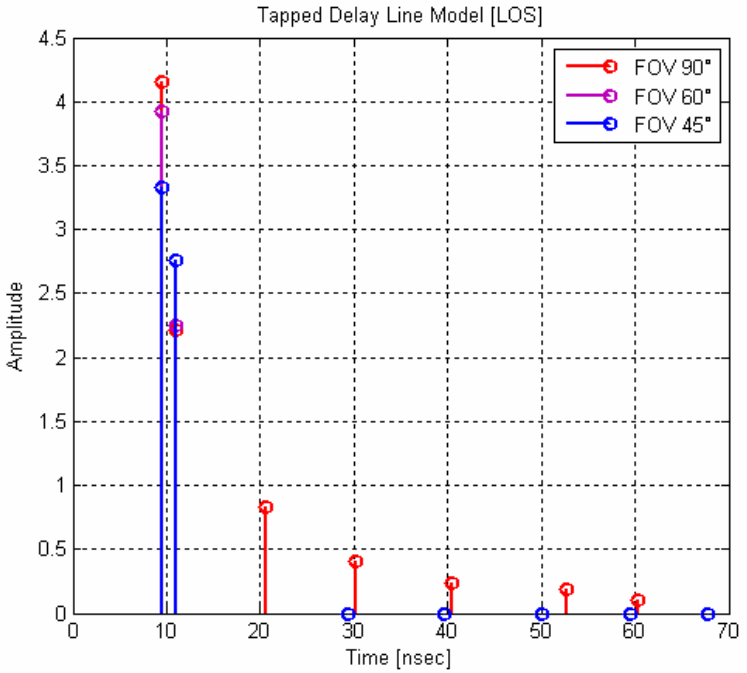
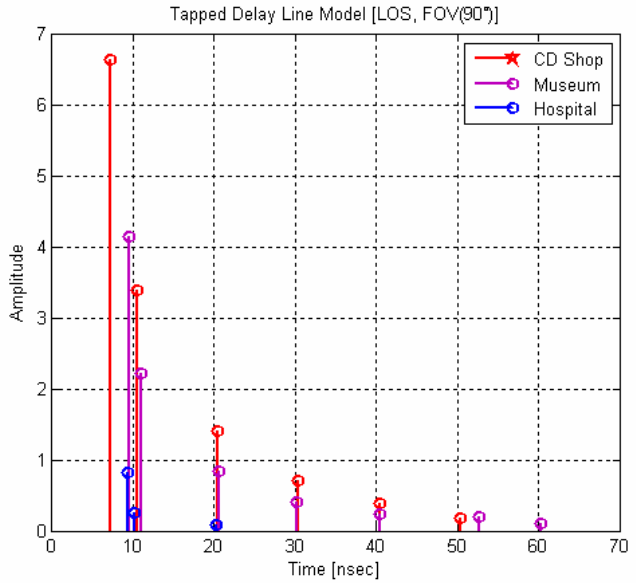


Channel modeling comparison in FOV 90° case

- Tapped delay line model in FOV 90 °
  - More LEDs, more power received (as expected)
  - Less LEDs, less multipath (as expected)



Future Works

- Channel modeling simulation
  - 2 more VLC modeling environments
    - Home, cafe
  - RGB LED channel modeling
  - Reflection
    - Diffuse, Glossy reflection simulation

Thank You~

Q&A