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

Submission Title: [Simulation of VLC between the Traffic Light and Vehicles]
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Abstract: [This document presents Simulation of VLC between the Traffic Light and Vehicles]

Purpose: []

Simulation of VLC between the Traffic Light and Vehicles

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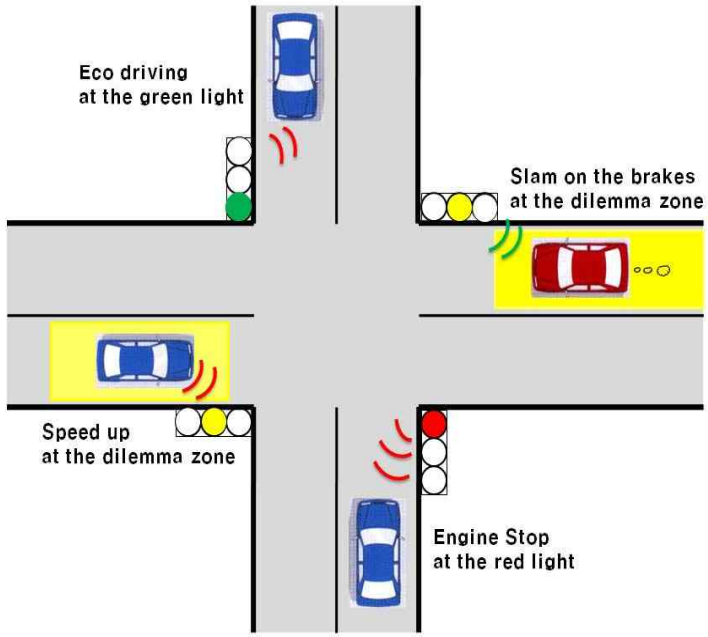
VLC application for ITS

- Benefits
  - VLC between the traffic light and vehicles help safer and more economic driving at green and yellow traffic lights and more fuel-sapping stops at red traffic lights
  - VLC offer easier traffic installation
- Regulation in South Korea
  - Height regulation of the traffic light
    - √ 6 m
  - Stop line regulation at the intersection
    - √ 20 m
  - Lane width regulation
    - √ 3.5 m



VLC system for ITS

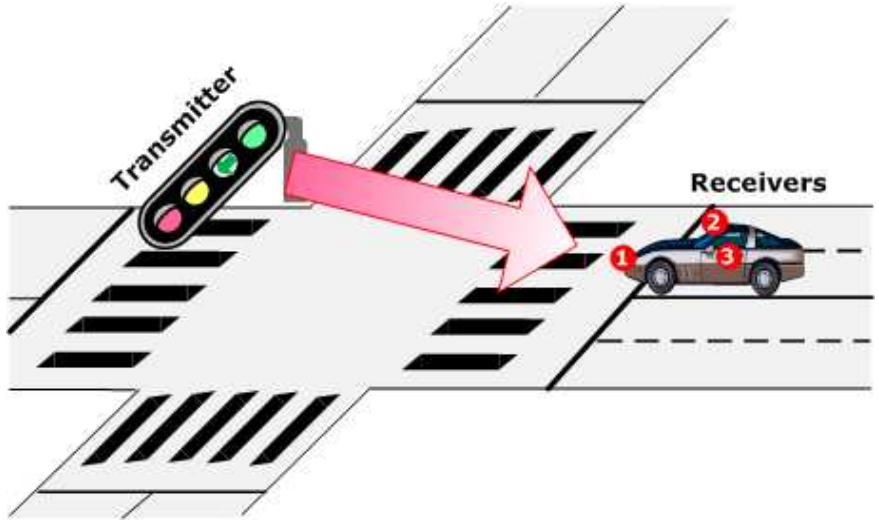
- Illuminating spaces with an optical wireless communication
- Alternative for wireless communication to enable infrastructure-to-vehicle communication in ITS
  - Traffic Light-to-vehicle : traffic information
  - Vehicle-to-vehicle : local information, temporary traffic congestion

- Motivation
  - Though simulation results based on traffic standards in South Korea, we show that VLC does not only ensure the required data rate but also reasonable performance

* ITS : Intelligent Transportation System

Simulation Setup

- Environment (Intersection)
  - Limited to two-lane road in each direction
  - Setting parameters following traffic standards in South Korea
    - ✓ Traffic light (4 types) : red, yellow, turning-left and green
    - ✓ Measurements of roadways, street crossings
- Equipments
  - Transmitter : LEDs in traffic light
  - Receiver(PD) positions
    1. Center of front bumper
    2. Top of windshield
    3. Both side mirrors (left, right)

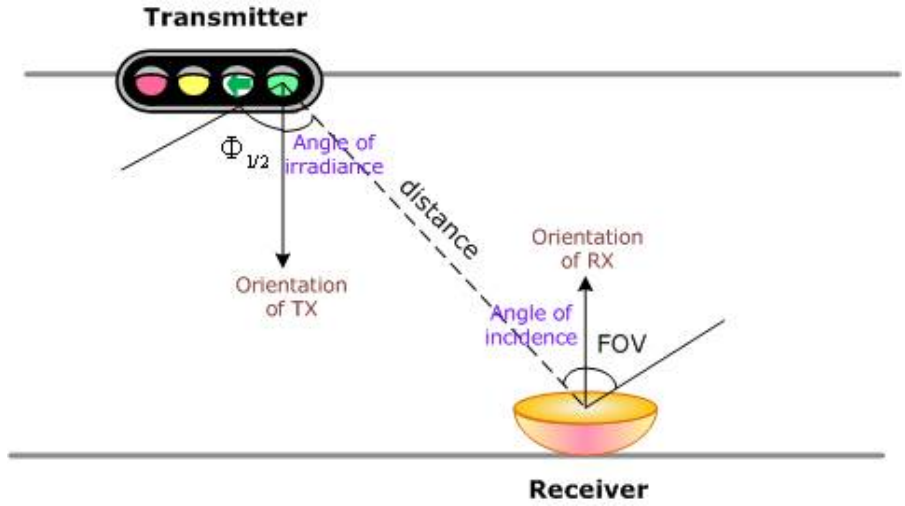


Wireless Optical Channel Model

- Line-of-Sight (LOS) case
  - No intersymbol interference (ISI) effect due to no multipath
    - ✓ ISI is a major impediment for reliable communication
    - ✓ If the environment with locating buildings in a distance from the intersection is assumed, we can make the problem simply with only LOS path because of negligible multipath effect at the intersection.
  - Received optical power (P_r)

$$P_r = H(0)P_t$$

* $H(0)$: channel gain
* P_t : transmit optical power



Performance Analysis

- BER performance for OOK modulation
  - Most efficient for binary modulation schemes in view of power, bandwidth and pulse shaping, etc.

$$BER = Q\left(\sqrt{\frac{S}{N}}\right)$$

S : signal power

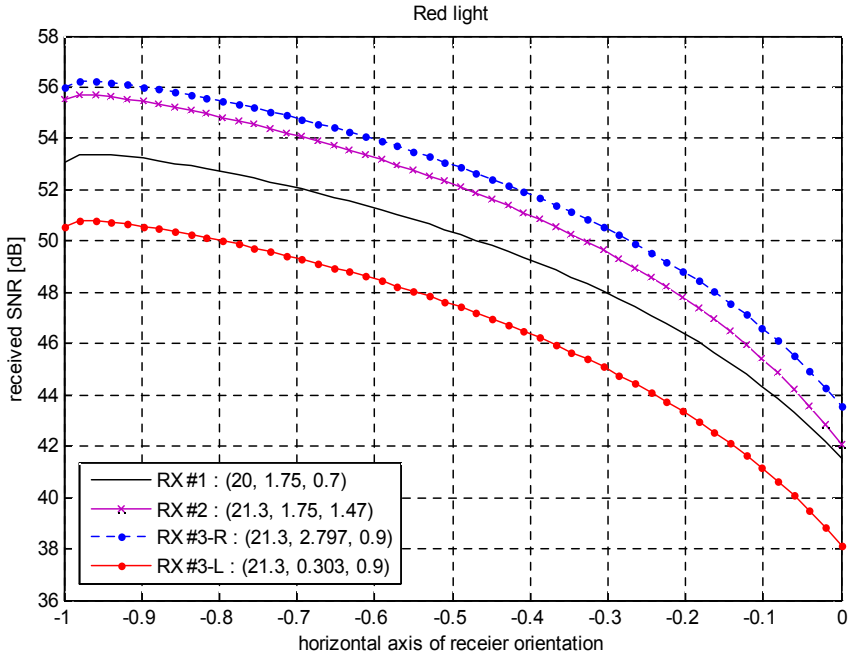
N : noise power

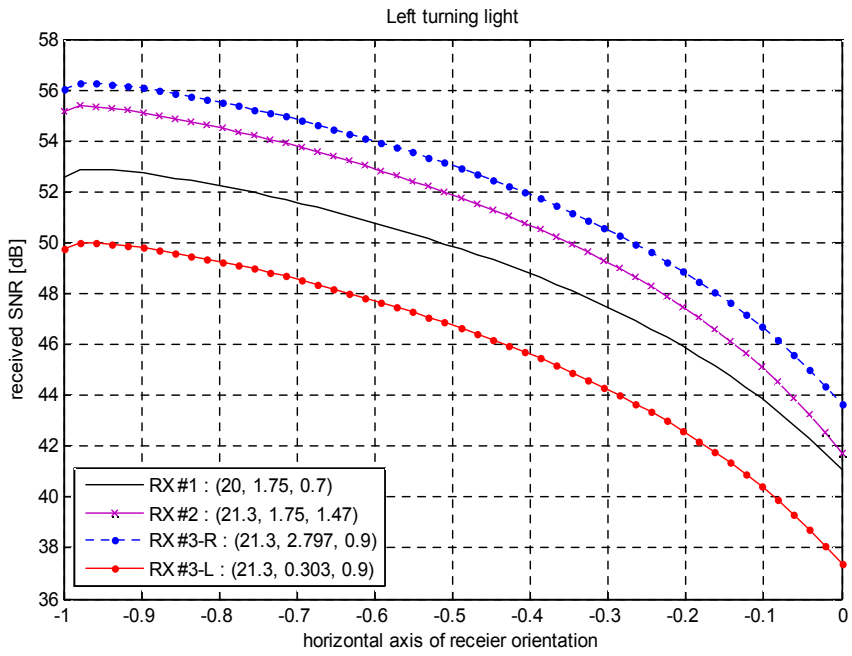
- Requirements
  - Target data rate : 10kbps ~ 100kbps
  - BER for stable communication link : 10^{-6}

- minimum SNR for OOK modulation = 13.6 [dB]

* OOK : On-off keying

Simulation Results





- Primary factors of change
  - Required data rate is enough to guarantee a favorable communication link
  - Performance depends on the receiver's position and orientation

Conclusion

- We focus on VLC system between the traffic light and vehicles
- Simulation results show that any receiver of all recommended positions can reliably communicate with required data rate, less than 100kbps

Next Step

- Consideration of diffusing components
- Impact of background noise power throughout the day

Thank you

- Q & A
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